THE EPIDEMIOLOGY OF TRICHOSTRONGYLID INFECTIONS OF SHEEP IN THE NORTHERN GUINEA SAVANNA OF NIGERIA

BY

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APPROVAL

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This Thesis is dedicated to the Memory of my parents Late Chief Bafon Ajayi Ogunsusi and Late Mrs. Lydia Funke Ogunsusi of Ile-Oluji.

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CHAPTER ONE

INTRODUCTION

Small ruminant production has always been an important source of meat in Nigeria. With recent meat shortage and the increasing costs, sheep and goats have assumed an even greater importance as a source of meat for an increasing larger number of Nigerians particularly in the rural areas.

Apart from the meat, there are other products like milk for consumption, skin which is used as raw material for local industries and for export, and the manure, for agriculture. Breeding sheep for wool is not yet a popular venture in this country.

Small ruminants generally suffer from parasitic diseases including gastro-intestinal helminthiasis. This is a polyaetiologic disease complex, causing low mortality except in acute haemonchosis in which mortality could reach high proportions. Similarly chronic development with high morbidity, reduces animal production.

In Nigeria, gastro-intestinal helminthiasis of sheep is usually produced by one or more of the following species of helminths:- Haemonchus spp. Trichostrongylus spp. Oesophagostomum spp; Strongyloides spp. Bunostonum spp. and Gaigeria sp. (Schillhorn, Shonekan and Fabiyi, 1975).

Among these, H. contortus, T. colubriformis, O. columbianum and G. pachyscelis are considered to be primarily involved in the disease complex in Nigeria (Kuil 1970, Schillhorn, 1973). The diseases produced by these helminths need to be controlled before animals are expected to give maximum yield. However, a scientific control program can only be viable when based on the knowledge of the biology of the parasites including the geoclimatic conditions of the environment which ensure the survival of the free-living forms. It is only after knowing these conditions that prophylactic control methods can be applied.

Of the helminth diseases in Nigerian sheep, the most prevalent and most pathogenic has been reported to be haemonchosis produced by Haemonchus contortus (Kuil, 1970). This is always accompanied by infection with Trichostrongylus spp.. Several different factors of importance like climatic conditions (Fabiyi, 1968 and 1970, Kuil 1970), periparturient rise in faecal egg counts (Van Geldorp and Schillhorn, 1976), and Inhibition phenomenon (Hart 1964), have been implicated in the epizootiology and pathogenecity of gastro-intestinal helminths under Nigerian conditions.

The purpose of this work therefore was to investigate helminthiasis in sheep under Nigerian conditions with emphasis on:
(1) the survival of the free-living stages of Haemonchus spp. and Trichostrongylus spp. on pasture in relation to infectivity.

(2) The epidemiology of the inhibited larval forms.

(3) Drug trials to find out which of the currently used anthelmintics and in what dosages would be most effective against the inhibited forms for effective prophylaxis.

(4) Blood pictures in acute and chronic helminthiasis.

CHAPTER TWO

REVIEW OF LITERATURE

The Biology of gastro-intestinal Trichostrongyles

Male and female sexes are separate and all females are oviparous. Fecundity which can be very high in certain genera depends on a series of factors like immune and health status of the host. A female Haemonchus spp. lays between 5000-10000 eggs per day while Trichostrongylus axei according to Leland (1963) lays on the average 27.9 eggs in 24 hours. However, Gordon (1967) believes that species of the latter genus produces between 100 to 200 eggs in 24 hours. Egg is ovoid with a thin transparent shell. When egg is fresh, the internal structure can be seen under the microscope. This consists of darkish blastomere which has already started segmentation. In certain genera for example Haemonchus, eggs are excreted from the helminth in the pre-morula stage while in others, eggs are already in the bastomer stage as is the case with the genus Chabertia.

Dimension of the eggs vary with the genus of the parasite. Some are as small as 60 microns in length and 30 microns in breadth as are found in species of Cooperia while others are as large as

260 microns in length and 110 microns in breadth as are found in the genus Nematodirus.

For the normal development of trichostrongyles, it is essential that their eggs pass through the external medium where their development depends on a series of physical, chemical and biological conditions. Normal development of trichostrongyles in the outside environment embraces the following stages: maturation of eggs, hatching, development of larva stage 1, moulting, development of larva stage 2, moulting, and development of infective larva. All these stages are influenced by outside conditions among which temperature, humidity, moisture, and oxygen are considered to be of major importance.

Temperature

A temperature range of 20°C and 30°C has been found to be most suitable for normal egg development. Above or below this, there is reduction in the capability of the egg to develop and may lead to their destruction.

Suteu (1955) in a series of laboratory experiments on Namatodirus follicollis, showed that at +37°C, after 48 hours, eggs developed into larval stage 1 but no hatching could take place and after 15 days all eggs had their contents disorganised. However,

at a temperature of between +15-21°C, development of eggs was slow and the first set of larvae were formed in the eggs after 2 weeks. As regards the effect of low temperature and freezing, he found that the eggs of N.filicollis do not develop at all at a temperature below +15°C.

Silverman and Campbell (1959) working with Haemonchus contortus, maintained that at 0°C, eggs did not develop. At +7.2°C, eggs passed from the blastomer stage to the morula stage in 8 days, a process which took only 2 days at +11°C and a single day at +14.4°C.

From the morula stage to the gastrula stage, they found that it took 18 days at +7.2°C, 3 days at +11°C and 2 days at +14.4°C. Eggs reached prehatching stage after 24 days at a temperature of +7.2°C, 8 days at +11°C and 5 days at +14.4°C. They concluded that at a temperature of +7.2°C eggs do not hatch unless they are given a temperature of at least +9°C. Rose (1963) showed that morulated eggs of H.contortus could resist freezing in a proportion of 100% for a period of 4 hours, 20% for 22 hours while at 24 hours, all were dead. However, embryonated eggs were alive in a proportion of 50% after 24 hours of freezing, but were all dead after 4 days. He pointed out that at +7.5°C, only up to 10% of the eggs reached embryonated stage but this proportion went up as high as between

60% and 90% at +11°C. Conway (1964) followed the development of the eggs of H. contortus and found that these get to pre-hatching stage in 12 days at +14°C.

Rose (1966) reported that morulated eggs of N. helvetianus could resist freezing in the proportion of 80% for 15 days and 74% for 10 weeks. All these investigations were carried out under controlled laboratory conditions. At the same time similar data were collected under field conditions. Generally, the results obtained under field conditions are comparable in certain aspects to those obtained under controlled laboratory conditions. Eggs develop better under fairly cool conditions than under low environmental temperature. It has been observed in temperate countries that during winter, the eggs of Haemonchus spp. and Oesophagostomum spp. are killed while those of Nematodirus spp. Ostertagia spp. and Trichostrongylus spp. are preserved. The eggs of Nematodirus spp. are able to survive on pasture all the year round.

Andersen, Levine and Marquiardt (1964) in the United States of America deposited eggs of C. onchophora, N. spathiger, T. colubriformis and H. contortus on pasture in November. On the 20th of April, they sampled the pasture and were only able to find the larvae of Nematodirus spp. and Cooperia spp. and concluded

that the eggs of the other 2 species were unable to survive the winter. Andersen, Boatman and Levine (1965) in a similar experiment deposited eggs of T. colubriformis on pastute and studied further the proportion of hatching in the different periods of the year. They reported that the best hatching percentage was obtained during May, June and July. Goncalves and Saraiva (1965) in Rio Grande do Sul had the belief that the eggs of trichostrongyles of sheep would survive on pasture only for 2 months during summer.

Donald (1968) reported that in Australia, the highest hatching percentage of nematode parasites of sheep was obtained from eggs exposed on pasture during September, June, April and May. According to Boag and Thomas, (1970) T. colubriformis and O. circumcincta produce very resistant eggs, which can survive the year round under different climatic conditions.

The resistance of the eggs of some trichostrongyles in the external environment to varying degrees of temperature is very important in the epidemiology of the disease.

The effect of moisture and relative humidity on egg development

Trichostrongyle eggs in order to develop well, need some degree of moisture. Usually this factor goes hand in hand with

temperature requirement and it is also as important. The degree of moisture also depends on the amount of rainfall in a particular environment.

Shorb (1943, 1944) working with H. contortus, found that eggs which have already reached the prehatching stage could resist dessication for just a few hours. Dinnik and Dinnik (1955) working in Kenya found that about 25.4 mm of rains for 10 days with a mean minimum temperature not less than 11.7°C were necessary for development of eggs of H. contortus to the infective larvae in the field.

In the opinion of Suteu (1955), the metabolic processes in a trichostrongyle eggs are produced variably with thermal variations.

Silverman and Campbell (1959) found that different stages of H. contortus eggs up to prehatching stage are quite sensitive to desiccation but the prehatching stage itself can survive for up to 6 weeks in dried faeces. Rose (1963) reported that embryonated eggs of H. contortus could survive dessication for just 24 hours. Belle (1959) remarked that the eggs of B. trigonocephalum would not develop at any temperature below 15°C or above 35°C. Deodhar (1965) stated that in a dry atmosphere, development of eggs of

Mecistocirrus digitatus is impeded and only very few will get to prehatching stage.

Under excessive humidity, hatching does not take place and the eggs get destroyed. This was the findings of Popescu (1967) working on some trichostrongyles of sheep in Romania. Soulsby (1968) indicated that embryonated eggs of all strongyles would survive some weeks under dry conditions while those morulated were quickly destroyed. Embryonated eggs however would not hatch unless optimum relative humidity is assured. It is quite evident from the above citations therefore, that environmental temperature and relative humidity would go together to determine egg development. The degree of egg resistance depends on its stage of development, (Dinaburg 1944, Gordon 1948) and for metabolic processes in the egg to go on normally and embryogenesis to occur, an optimum relative humidity must be assured.

The effect of light

All other conditions assured, trichostrongyle eggs will develop well either under darkness or light but rate is slowed down under darkness. Dinnik and Dinnik (1958) placed some faecal pellets with eggs of H. contortus on grass under a shaded tree,

another sample was placed under a tree with reduced foliage which was well exposed to light. They found that development was greater in pellets kept under a tree with shade. Development of larvae was hampered in the pellets which were exposed to strong sunlight.

Popescu (1967) reported that with trichostrongyle eggs, after 24 hours incubation in the dark a contour of the larvae was observed in the egg shell and after 48 hours, eggs were already hatching in increasing number up to 7 days. In the culture exposed permanently to light, all the eggs were hatched within 5 days.

Effect of oxygen

Trichostrongyle eggs do not develop under anaerobic conditions. Oxygen is necessary for their development. According to Michel (1956) when a pasture is flooded, the respiration of strongyle eggs is interrupted, leading to their death. He explained that loose soil and sandy soils which are well aerated favour egg development, whereas impermeable and clay soils impede aeration and lead to destruction of eggs.

Blood and Henderson (1968), Lapage (1968) and Soulsby (1968) have stressed the fact that trichostrongyle eggs develop normally and metabolic processes run their normal course only in the presence of oxygen.

Normal development of trichostrongyle eggs

In the environment, oxygen, optimum temperature and moisture being available, eggs start their development. When freshly laid, the content is darkish and segmentation is at the stage of 2 to 8 blastomers. Five hours after excretion from the helminth, the content of the blastomers turns faint, spreads in the egg and becomes transparent. The clearing process starts from the periphery towards the center. After 8-9 hours, the content becomes granulated, and there appears a muriform mass which takes an elongated shape and little by little, a contour of the larva is formed. The larva now starts to move in the egg shell. This form of embryonated egg is extremely resistant to environmental conditions.

Andersen, et al., (1966) reported that embryonated eggs of T. colubriformis could survive for 2 days at -95°C and that at a stage just before hatching, the egg could survive for 64 days at -95°C.

Popescu (1967) observed that after 36-48 hours incubation, trichostrongyle egg had in it a coiled larva with visible movement. This larva at the beginning, had uniform colour but with some dark points all over. Soulsby (1968) found that embryonated egg survive even at temperatures below 0°C and also could resist desiccation for some weeks.

Under optimum conditions, trichostrongyle eggs liberate the first stage larvae or L_1 by the process of hatching. The success or failure of eggs to hatch depends on a series of factors of which the

following are the most important: Environmental temperature, Genus and species of the parasite, variety and Individuality of the parasite and Egg volume.

Effects of environmental temperature on egg hatching

As mentioned earlier on, the normal development of an egg requires a temperature of between 20°C and 30°C. However the temperature needed for the hatching process can vary a great deal.

Shorb (1943) and Dinaburg (1944) working on H. contortus in America, found that the lowest temperature at which eggs of this species could hatch was +18°C. In Scotland, however, Silverman and Campbell (1959) indicated that eggs of H. contortus would hatch even at temperatures as low as +9°C.

In contradiction to many other authors, Ciordia and Bizzel (1963) found that there did not exist any important difference in the embryogenesis, hatching and larval development of C. punctata, C. oncophora, O. ostertagi, T. axei and T. colubriformis. They indicated that eggs of these species would hatch at a temperature between +6°C and +35°C.

Temperature requirements by some trichostrongyle eggs for hatching as reported by Crofton (1965) and Crofton and Whitlock (1965a) are summarized in Table I.

Table 1

Temperature requirements for egg hatching of some trichostrongyle species

Species	Temperature range for egg hatching °C		
O. circumcincta	+4	---	+34
C. ovina	+6	---	+36
T. axei	+8	---	+36
H. contortus	+9	---	+36
C. oncophora	+15	---	+38
B. trigonocephalum	+15	---	+34
C. curticei	+16	---	+38

It could be seen from this table that C. curticei, C. oncophora and B. trigonocephalum need relatively high temperature for their eggs to hatch while those of O. circumcincta and C. ovina may hatch even under fairly low temperatures.

Effects of Genus and species of the parasite on egg hatching

Hatching takes place after a certain period of incubation. This period may be short or long depending on the genus to which the parasite belongs. In Nematodirus, a genus in which all the first 3 larval forms are formed in the eggs, hatching does not take place until about 2 to 4 weeks under optimum conditions. In the genus Haemonchus, all conditions being optimum, hatching can occur between 12 to 24 hours while in Trichostrongylus spp. hatching occurs in 3 to 5 days.

Suteu (1955) concluded that at +26°C, the eggs of Nematodirus spp. would hatch after 2 weeks while in his work on different species of Nematodirus, Thomas (1959) found that at +21°C, eggs develop to prehatching stage in the following interval:

N. helvatianus	after	17-20 days
N. spathiger	after	18-22 days
N. filicollis	after	24-27 days
N. battus	after	28-30 days

Rose (1966) showed that eggs of N. helvetianus when cultured on wet faeces at a temperature of between +25 and +26°C would hatch after 13 to 168 days while at +20°C, hatching time was between 30 and 180 days.

In dried faeces, at a temperature of between +25 and +26°C, the eggs hatched in 14 to 278 days and at +20°C, they hatched in 22 to 310 days.

Soulsby (1968) found that the eggs of N. battus do not hatch spontaneously but must be subjected to alternating high and low temperatures like -2°C and then exposed to +21°C. He also stated that apart from the eggs of Nematodirus spp. eggs of trichostrongyles belonging to other genera would hatch in 20-24 hours at +26°C.

Effects of variety and individuality of the parasite on egg hatching

There is a great variation between development and hatching of eggs from the same species of trichostrongyle belonging to different strains. In their investigations on O. circumcincta, Crofton and Whitlock (1965a) found that in the strain from Bristol, hatching did not take place at temperatures above +34°C or below +4°C while in O. circumcincta obtained from Cornell, hatching could take place between +10°C and +38°C. Crofton, et al., (1965) working with H. contortus, showed that embryonated eggs of the strain from Bristol would hatch at

temperatures between +9°C and +36°C; those from Cornell would hatch at between +15°C and +41°C, while those from Kentucky would hatch at between +15°C and +40°C.

Not all the eggs in a culture incubated at the same time and under the same conditions develop simultaneously. Crofton et al., (1965) observed 3 types of Haemonchus spp. in Cornell using a vulvular structure as the criterion for differentiation. These types are smooth, linguiform and knobby types. From their results, it was evident that at +40°C, only the eggs from the smooth type would hatch after a period of incubation of 14.5 hours. The other 2 types did not hatch. At a temperature of +26°C eggs of the smooth type hatched after +18.5 hours, while eggs of the other 2 types hatched after 18 hours. Similarly, when the eggs were incubated at +17°C, eggs of the smooth type hatched after 67 hours while those of the other 2 types hatched in 67.5 hours.

The explanation for this strain variability may be attributed to the genetic constitution of evey helminth.

Effects of egg volume on egg hatching

The time needed for a trichostrongyle egg to hatch is directly proportional to the volume of the egg.

Crofton and Whitlock (1965b) observed that the larger the volume of an egg, the longer it takes to hatch. They concluded that the minimum volume of eggs of a species determine the minimum time necessary for hatching at a certain temperature whereas the maximum volume will determine the maximum time necessary. This observation is however only theoretical, since there are several other extrinsic factors that control hatching.

The larval forms of trichostrongyles

A trichostrongyle larva passes through 5 stages of development, 3 of which occur in the external environment and 2 stages in the animal host.

The first larval stage is elongated, sharper at one end, with a rudiment of buccal orifice. The cuticle is uniform light brown and covers the whole body length. It is a free-living form and feeds entirely on bacteria from the soil and faeces (Soulsby, 1968).

After about 24 hours, under optimal conditions, this first stage larva takes a lethargic position in preparation for a moult. It moults into second larval stage. This form is similar to the former except that the body is more developed and movement is more vigorous.

In another 24 hours under optimal conditions, the second stage larva moults into the third larval stage called the infective larva, (Niculescu 1968, 1969, Niculesu and Lungu 1968). The third stage larva remains covered with the cuticular covering of the second stage larva. Infective larva does not feed but lives on the reserves of its intestinal cells and up to a particular stage, if it is not ingested by a host, the intestinal reserves are exhausted and it dies off.

The time necessary for development from egg to the infective larva depends among other things on the genus of the parasite. Under optimal conditions, it takes the following days for the different genera to reach the infective larval stage (Table 2).

Table 2

Duration of development from eggs to infective larvae in some trichostrongyles*

Genus of parasite	Duration of development from egg to infective larvae in days
Haemonchus	3-5
Ostertagia	4-6
Trichostrongylus	3-7
Bunostomum	3-7
Chabertia	3-6
Oesophagostomum	3-7
Cooperia	3-7
Nematodirus	21-28

* Adapted from Niculescu (1968) and Soulsby (1968)

Silverman and Campbell (1959) stated that from eggs to the infective larva stage, it would take H. contortus 15 to 20 days at a temperature of +11°C while it takes only 3-4 days at +37°C. Rose (1963, 1966) indicated that eggs of H. contortus developed to infective larvae in 3-5 days at +25 to +26°C and 15 to 30 days at +10 to +11°C. With eggs of N. helvetianus cultured in wet faeces, development to infective stage took 12 to 41 days at +16 - +26°C. From these results, it is evident that as temperature is near to optimum so also development to infective larvae is more rapid.

The resistance of larvae stage one and stage two

These 2 larval forms do not present much importance due to the fact that they are not infective to the host. Their resistance in the external environment is very low. According to Rose (1963), the stage one and stage two larvae of H. contortus could survive freezing at -6°C in proportion of 60% for 12 hours and proportion of 10% for 23 hours. He also sustained that at desiccation, the larvae will all die in less than 24 hours. Andersen, et al., (1966) worked on larval stage 1 of T. colubriformis. They found that this could survive for 4 days at a temperature of -95°C whereas larva stage 2 could survive

32 days at similar temperature. Furthermore they discovered that at +4°C, only 15% of larva stage 1 could live up to 64 days whereas under similar conditions only 14% of larvae stage 2 wer alive. According to Blood and Henderson (1968) larval stage 1 and stage 2 of C. ovina are reasonably resistant to cold weather and Donald (1968) maintained that fluctuations in meteorologic conditions have a serious effect on the development and survival of larvae stages 1 and 2.

Lapage (1968) reported that stages 1 and 2 larvae are quite sensitive to humidity and temperature and this is why many of them die off before they ever reach the infective stage.

The infective larva

The morphological features of the infective larva vary with the species and these are described by Douvres (1957). It is the most resistant larval form and the only element of infection. It migrates on plants or buries in the vegetative mass under plants. This larval form prefers dark and wet places and they are much more active at night or late in the evening. When active, they climb vertically on grass blades. Their resistance is conferred by the cuticular covering which they inherited from larva stage two.

The resistance of infective larvae in the environment has been subject of considerable study. Laboratory and field studies have been carried out to evaluate the resistance against the following environmental physical factors:- temperature, moisture and relative humidity, soil type, light and solar rays.

Effects of temperature on the infective larva

The optimal temperature for larval activity is between 26-28°C. If temperature in the environment is too low, trichostrongyle larvae are not able to effect their migration on grass and leaf blades. The optimal temperature for infective larval survival is between 4°C and 6°C (Gevrey, 1969). Larval resistance to temperature is a function of the genus to which the parasite belongs. Some are very resistant to temperature such as Nematodirus spp. Ostertagia spp and Trichostrongylus spp. while others are less resistant (Cooperia spp. Mecistocirrus spp. Oesophagostomum spp. and Haemonchus spp). Poole (1956) made an observation on Nematodirus filicollis that the infective larvae could survive temperature range of between -65°C and +74°C and that 22% of the larvae would survive for 22 weeks at a temperature of -6.5°C.

The infective larvae of H. contortus, according to Rose (1963) could survive freezing at -6°C in the proportion of 100% for a period of 5 hours and in the proportion of 15% for 11 days. Under similar conditions, the larvae of N. helvetianus survived in the proportion of 100% for 4 days, 60% for 19 days and 13% for 105 days (Rose 1966). He did mention that at a temperature of +7°C, the larvae of this species survived 100% for 5 months and 20% for 20 months whereas at +26°C. 95% survived for 4 weeks and 20% for 3 months.

Under temperate conditions, it was found that the infective larvae of H. contortus, T. colubriformis, C. curticei and O. columbianum could survive for 4 months during winter and for only 4 weeks during summer (Goncalves and Saraiva, 1965). The resistance of the larvae of B. trigonocephalum was tested by Narain (1965) and his findings showed that at +5°C, the larvae survived for 70 days while at +40°C, they survived for 5 days. In their own contribution to this subject, Andersen, et al., (1966) investigated the survival of T. colubriformis infective larvae at very low and very high temperatures. At -95°C, the larvae were still alive in the proportion of 100% after 64 days, 100% after 308 days at +40°C and 75% after 425 days at +40°C. This is the first recorded work in which infective larvae have been subjected to such extremes and in which they are found to survive for over one year at such a high temperature as +40°C.

On a field observation, Williams and Mayhew (1967) found that the infective larvae of C. punctata, T. axei and O. radiatum could survive for up to 5 months in autumn and the first part of winter. In the temperate, at this period of the year, environmental temperature is fairly low and there is plenty of moisture. Chabra and Singh, cited by Shanker (1970) worked with O. columbianum under laboratory conditions and found that the larvae could survive the temperature of -18°C in the proportion of 8.6% for a period of 18 hours, 10.3% for 7 days at 0°C and 8% for 28 days at +37°C. Shanker (1970) working with the same species, found that at -18°C, 72% of the larvae lived for 8 hours, and 3% for 18 hours. At 0°C, he found that 92% were still living after 4 days and 30% after 7 days. At +4°C, 70% were alive after 26 days. 69% of them lived for 56 days at +25°C and 81% lived for 28 days at +30°C.

In a recent work, Ardo (1977) working with the infective larvae of H. contortus found that all those incubated at 50°C died within 45 minutes, those at 40°C were all dead after 6 weeks and at 0°C none did survive beyond 8 weeks. More than 50% of those incubated at 26°C were still alive after 16 weeks.

Andersen, et al., (1965), Rose (1963, 1966), Donald (1968), Boag and Thomas (1970) and several others arrived at the conclusion that the longevity of infective larvae of the different trichostrongyle species, varies between 8-60 weeks depending on the season of the year. The climatic conditions during autumn and winter in temperate countries are not suitable for larval survival while in tropical climates, the high temperature during the dry season is lethal to the larva.

Larval resistance to relative humidity, moisture and dryness

The relative humidity of an area is conditioned by the amount of moistute in that area. The two, are important factors for trichostrongyle infective larvae in that they affect larval migration. However, too little or too much is quite destructive to the larvae.

Rose (1963) desiccated some larvae of H. contortus in an atmosphere with a relative humidity of 90% and found that up to 93% of them lived for 3 days and only 10% survived up to 50 days. When desiccation was carried out in an atmosphere with relative humidity of 30%, 95% of the larvae lived for 24 hours and after 4 days, only 6% were alive.

Based on their field observation, Silangwa and Todd (1964) had the opinion that larval activity is activated by humidity, because they find that most larvae were found on wet grass blades and only very few were found on dry grass. The reason why the larvae of O. ostertagi survived the greatest during autumn and winter is due to the fact that there is favourable humidity coupled with a not very high temperature (Williams, 1965).

On T. colubriformis, Andersen and Levine (1968) tried desiccation at -95°C and found that some of the larvae were still living after 128 days. When desiccated at -20°C about 5% of the larvae were alive after 128 days. This shows that desiccation under low temperature is not as drastically lethal to larvae as is desiccation under high temperatures.

Migration on vegetation is the main activity of infective larvae since this facilitates their being picked up by the grazing host. According to Soulsby (1968), for this migratory activity, a maximum of 0.12ml of water per square centimeter of soil is essential and according to Steward and Douglas cited by Tripathi (1969), larvae of T. axei are able to survive for up to 230 days in water at a depth of 5 mm. Tripathi (1969) immersed some trichostrongyle larvae in water and followed their development. He observed that the infective larvae of Haemonchus spp.

died in a proportion of 87.5% after 35 days at 1 cm. depth while 90% died after 95 days at 4 cm. As for Oesophagostomum spp., 50% died after 35 days at a depth of 1 cm. and 100% died after 40 days at 4cm. Under similar conditions, the larvae of Trichostrongylus spp. resisted up to 80 days at a depth of 1 cm. and up to 60% had died after 40 days at 4 cm. Shanker (1970), coupled the effect of temperature with that of relative humidity, and found that under laboratory conditions, the larvae of Oesophagostomum spp. are quite sensitive to dryness. At a temperature of +25°C with a relative humidity of 100%, he found that 73% of the larvae survived more than 25 days. When relative humidity was 75.5% with temperature of 30°C, only 30% of the larvae lived for more than 25 days.

It is clear from this review therefore that too high relative humidity coupled with low temperature is destructive to infective larvae.

Effect of soil type on infective larvae

As in the case of eggs, the survival of infective larvae depend on type of soil on which the larvae live. An impermeable soil that retains water on the surface is destructive because it favours high

humidity and blocks aeration of the soil. Deodhar (1965) cultured some infective larvae of M. digitatus on dry sand and found that all of them were dead within 72 hours.

A soil with good runoff, plant cover and good management is quite ideal to infective larvae since this type of soil will have a micro-climate which is favourable for larval development. Furman (1944) observed that the larvae of O. circumcincta were rapidly killed during summer on a non-irrigated pasture but those in irrigated pasture survived.

Larval resistance to light and solar rays

Trichostrongyle larvae show moderate phototropism. Rogers (1940) reported that larval migration was influenced by light intensity. He observed that the greatest larval movement was at 62 foot candles. According to him, a large number of larvae were recovered from grass blades and leaves very early in the morning. This view has been confirmed by Soulsby (1968).

Direct sunlight is lethal to infective larvae due to the ultra violet rays. According to Gupta (1961) far ultraviolet light (2800^{o}A or less) would kill infective larvae of T. retortaeformis in less than

one hour. Parnell (1962) thought that the rapid death of the larvae of Trichostrongylus spp., Ostertagi spp. and Chabertia spp. on pasture during spring was due to exposrue to sunlight. According to Deodhar (1966) the rapid death observed in Mecistocirrus digitatus was due to dehydration caused by solar rays. Das (1968) collected some trichostrongyle larvae into a jar and placed this jar under an electric bulb. He concluded that due to negative phototropism to strong light, the larvae quickly withdrew to the bottom of the jar.

Longevity and infectivity of infective larvae on pasture

It is a well known fact that although infective larvae may survive on pasture for any given period of time, they do not remain infective to the host throughout that period. Between longevity and infectivity of these larvae, however, there is a correlation. Many researchers have studied longevity by single grass sampling while infectivity has been studied by the use of tracer lambs.

Sarles (1943) stated that the winter was too cold and the spring was too dry for the larvae of O. columbianum to survive. It was concluded that infection must have been passed on from year to year by

the persistence of the adults in the host. Dinaburg (1944) investigated the longevity of H. contortus during 4 seasons of the year by spreading infective larvae on plots and later on made larval recoveries. He was able to recover just about 1% of the larvae he deposited after 2 months during spring, 1% after 2 to 4 weeks during summer, 1% after 6 to 9 weeks in autumn and 1% after 4 to 6 weeks in winter. After 14 weeks in spring, 6 weeks in summer, 45 weeks in autumn and 12 weeks in winter, no more larvae were recovered. Hawkins, et al., (1944) were of the opinion that under the conditions existent in the state of Michigan, H. contortus larvae could survive for up to 2 months on pasture during late summer and fall while those of O. columbianum would survive for 3½ months. Those of O. circumcincta, T. colubriformis and Nematodirus spp. were still recovered on pasture after 4½ months.

Working in the northern part of the United States of America, Seghetti (1948) found that range lambs acquired infection especially during May and June, a period with the heaviest rainfall. From the middle of July, the range was free from the infective larvae of H. contortus and Trichostrongylus spp. due to inadequate moisture.

Dinnik and Dinnik (1955) found that the infective larvae of H. contortus did not survive for more than 10 days during the dry season

in the highlands of Kenya. Further studies (Dinnik and Dinnik 1960) indicated that during the rainy season in Kenya, up to 10% of the infective larvae of H. contortus could be recovered after 30 to 65 days of exposure, but during the dry season which is also usually hot, no larvae would survive for more than 5 days. All the larvae deposited on pasture at the beginning of the cold season survived till the end. This was confirmed by Allonby and Urquhart (1975).

In the Soviet Union, it has been observed that the infective larvae of O. ostertagi develop from April to September but when incorporated in faecal pellets and pads, could remain alive for a whole year (Bessonov, 1958). In Czechoslovakia, during the period of September to May i.e. autumn, winter and spring, temperature is below 30°C. It has been observed at this period (Erhardova, 1962) that the larvae of Ostertagia spp. and Nematodirus spp. could survive very well on pasture. Cooperia spp. also was found to have survived the winter in small quantity but the hookworm Bunostomum spp. did not. Larvae of T. colubriformis put on plots in late autumn, winter and early spring, survived better than those put on plots during summer (Andersen, et al., 1970). These authors also found that larvae could survive even when grasses were dried up.

The survival of infective larvae of trichostrongyles varies from one place to the other and the longevity of the larvae varies from one season of the year to another.

Under Nigerian conditions, Sprent (1946) and Lee et al., (1960) failed to recover infective larvae of trichostrongyles during the dry season months at Vom. Pabiyi (1968) studied the effects of physical environmental factors on the helminths of goat in the Zaria area and Kuil (1970) carried out similar studies on sheep. They both found that the conditions of the dry season were not favourable for the survival of the infective forms of trichostrongyles and as a result, no infection occured during this period, but during the months of May to September, conditions on pasture were favourable for larval development. According to Okon (1975) infective larvae of various trichostrongyles were recovered from pasture in Ibadan during May to October.

Destiny of the infective larvae

The infective larvae, if not acquired by a host within a certain time, will be exhausted and die off. If they are picked up, however, they start the second phase of their development called the parasitic phase.

Entrance into the host may be oral i.e. together with feed or water or through the skin as in the case of hookworms and Strongyloides spp. On entering the host, those that normally live in the abomasum will exsheath in the rumen while those that live in the intestine carry out their exsheathment in the abomasum. This process of exsheathment is to throw off the cuticular covering which had been inherited from the free-living second stage larva. According to soulsby (1968), the process of exsheathment embraces 2 phases:

a) A stimulus produced by the host makes the infective larva to secrete an exsheathing fluid.

b) The secreted exsheathing fluid attacks the cuticular covering and gets it dislodged.

In about 3 to 4 days after ingestion, the infective larva moults to larva stage 4 and in another one week, this reaches maturity, (Veglia, 1915). During their course of development, the different larvae spend some time in the mucosa of the gut. According to Niculescu (1968), the larvae of Trichostrongylus spp. keeps 4 to 5 days in the crypts of the gut wall. After this pause, the larvae are transformed into stage 5 larvae and return into the lumen of the gut.

Reproduction takes place in the gut of the host. Fertilized eggs excreted by the female helminth pass out with faeces of the host and the cycle starts all over again.

The peripaturient rise and the spring rise in trichostrongyle egg production

The peripaturient rise has been described in Nigeria by Fabiyi (1973) and Van Geldorp and Schillhorn (1976).

It was first observed by Taylor (1935) who then concluded that the rise in trichostrongyle egg counts during February and March in housed ewes was due to the fact that adult worms in the gut increased their egg production, due to the stress of lambing and lactation. This same view was held by Morgan and Sloan (1947), Cushnie and White (1948), Spedding and Brown (1956).

After detecting the periparturient rise in sheep in Nigeria, Van Geldorp and Schillhorn (1976) suggested that the increase was due to helminths, mainly Haemonchus spp. which had been inhibited during the dry season and resumed their development at the beginning of the rainy season.

As to Spring rise, Soulsby (1957) thought that this was due to a weakening of the immune status of the host since no infective larvae were acquired in winter to keep on stimulating immune response.

However, Morgan, et. al. (1951) in Scotland, attributed the spring rise to newly acquired infections which caused an increase in worm load of the host and consequently an increase in egg production.

Field, et.al., (1960) reported that the spring rise was due to the developing larvae which have been undergoing the histotrophic phase and were maturing. The same view was held by Gibbs (1964). According to O'sullivan and Donald (1970), spring rise was due to a temporary depression of immunological capacity brought about by endocrine changes associated with lactation, which could result in a resumption of development of inhibited larvae, an increased rate of establishment of newly ingested larvae and an increased fecundity of female worms.

The inhibition phenomenon (Arrested development)

The occurrence of arrested development in animal parasitic nematodes has frequently been recorded in the literature, although the mechanisms involved in the phenomenon and the trigger leading to subsequent maturation of the worms remain obscure.

Infective larvae of H. contortus ingested by sheep normally undergo development through a series of moults to become mature adults, a process that takes 14 to 15 days (Veglia, 1915). In some circumstances, however, such larvae may arrest their development at an early L_4 stage 3 to 4 days after ingestion (Blitz and Gibbs, 1971b).

In Nigeria, the epidemiological significance of the inhibition phenomenon in sheep has been largely overlooked, although recent studies (Kuil 1970, Okon 1975, Van Geldorp and Schillhorn, 1976) have gone some way to correcting this ommission. Hart (1964) found that the adult worm burdens of Haemonchus spp., T. axei and O. radiatum were heavier at the end of the dry season. These increases were associated with rising egg counts and were evidently due to augmentation of the existing population when inhibited immature stages resumed development.

Van Geldorp and Schillhorn (1976) suggested that the similar increase in egg production which they detected in sheep was due to helminths, mainly Haemonchus spp. which had been inhibited during the dry season and resumed their development at the beginning of the rainy season.

Gordon (1952), Martin, et al., (1957) and Parnell (1963) indicated that nematodes which are inhibited in their parasitic development are

capable at a later stage of resuming their development. Sommerville (1953, 1954) recorded a varying proportion of inhibited histotropic larvae that failed to develop for up to 3 months post infection.

Between December and March, Gibbs (1967) found that over 95% of the H. contortus recovered from a small group of ewes were inhibited at the early L_4 stage under the conditions existing in Canada and similar results were recorded by Blitz and Gibbs (1971a) in a group of naturally infected ewes and lambs autopsied during winter.

Not all the larvae acquired on pasture go into inhibition. According to Michel (1969) only a small and relatively constant proportion of those ingested is inhibited.

Rogers and Sommerville (1969) noted that in most cases, development is arrested at a precise point for a given species, usually during lethagus, shortly before a moult, suggesting some association between these 2 phenomena.

The morphological characteristics of an inhibited larva was described by Blitz and Gibbs (1971b). The larvae remained as they were 3 to 4 days post infection with no differentiation of the genital primordium apparent. They also made mention of conspicuous crystals

observable within the intestinal cells of the inhibited larvae.

Causes of inhibited development

What are the factors that influence or cause ingested larvae to go into inhibition?

Gibson (1953), Roberts and Keith (1959), Dunsmore (1963) and Michel (1971) suggested that adult helminths suppress the development of concurrent immature infections which are only free to develop when the adult parasites are expelled. This suggestion has been rejected by Blitz and Gibbs (1972a) who cited instances in which large populations of inhibited larvae have been found in the presence of many adult parasites.

Dunsmore (1960) indicated that the inhibition of larval development is more pronounced following heavy infections. Again, Blitz and Gibbs (1972a) disproved this since the proportion of inhibited larvae of H. contortus which they observed during the winter exceeded 90%, irrespective of the total number of worms recovered. According to Madsen (1962) and Michel (1968), inhibition is produced by an interraction between the resistance of the host and the viability of the parasite. Dunsmore (1965) and Gibbs (1967) linked the phenomenon to seasonal changes in the physiology of the host and possibly of the parasites as well.

Working with Obeliscoides cuniculi, Stockdale et al., (1970) demonstrated that after ageing the infective larvae under constant conditions, up to 30% of the worms were inhibited as fourth stage.

Blitz and Gibbs (1971a) contended that the presence of populations of inhibited gastro-intestinal nematode larvae in sheep throughout the winter was not due to an inhibitory action of the hosts immune system. Soulsby (1966) postulated that the spring rise was being facilitated by the immune status of the host.

Apart from the belief that the age of the recipient can influence the phenomenon, Connan (1975) believed that seasonal inhibition of H. contortus in East Anglia is brought about primarily by environmental stimuli acting on the preparasitic stages.

Helminth species that go into inhibition in sheep

Inhibited development has been recorded in Haemonchus contortus, Ostertagia circumcincta and Trichostrongylus spp. infections in sheep. In the first 2, inhibition occurs at the early L_4 stage (Sommerville, 1953, 1954; Blitz and Gibbs, 1971a,b) and in the third species, it occurs at the L_3 stage (Michel, 1952).

Gibbs (1967), Connan (1968), Muller (1968), Blitz and Gibbs (1972a) have confirmed that the parasitic stages of H. contortus over winter as inhibited fourth-stage larvae rather than as adult worms in pregnant and non-pregnant sheep. In East Anglia, no evidence of inhibited development of T. axei was found during the winter by Connan (1968), and by Blitz and Gibbs (1972a) in Canada but Muller (1968) found that this species was inhibited at the larval stage 5.

The induction of inhibited development

In 1965, Dineen, et al., demonstrated that after infecting lambs with a daily dose of one hundred L_3 of H. contortus for thirty days, up to 35% of the ensuing infection was inhibited at the L_4 stage compared to 2% in lambs infected only once with three thousand L_3, suggesting that development was inhibited as the lambs acquired resistance to the parasites. Blitz and Gibbs (1972a) reported that inhibited development of early L_4 of H. contortus is induced in autumn by the prevailing environmental conditions, acting on the third stage larvae on pasture.

The duration of inhibited development

The maturation of inhibited larvae acquired in the autumn may be responsible for later outbreaks of winter haemonchosis Gibbs, (1964); Wilson and Samson (1970) and this may also make a significant contribution to the rise in faecal egg counts of lactating ewes in the spring Field, et al., (1960) Procter and Gibbs, (1968).

Blitz and Gibbs (1972a) indicated that during the winter, the condition of arrested development is maintained by a process analogous to diapause development. In spring, development recommences spontaneously on completion of these processes.

They also demonstrated that inhibited larvae of H. contortus are transitory since such forms may be recovered from housed sheep at least 4 months after removal from pasture.

In contradiction to reports of Gibbs (1967), Connan (1968), Muller (1968), McKenna (1974b) observed that although inhibited larvae of H. contortus are capable of persisting for a considerable period in sheep, and eventually resuming their development, the bulk of them are lost within 10 weeks of establishment without attaining sexual maturity.

Termination of inhibited development

The factors which cause the resumption of development are complex and are not necessarily a mere reversal of the causes of inhibition (Madsen, 1962; Michel, 1968) and resumption of development is constantly in small numbers (Michel, 1952; 1953).

Gibson (1953) observed that when adult Trichostrongylus spp. were removed by anthelmintic treatment from aged horses which were prevented from reinfecting themselves, the faecal egg counts rose again after a time and further crops of worms could be removed by subsequent anthelmintic treatments. On each occasion, the dead worms could be demonstrated in the faeces. He concluded that the removal of the adult worms had stimulated the development of inhibited forms lying latent in the mucosa.

Similarly, following the removal of adult worms by anthelmintic treatment, Dunsmore (1963) recorded an increase in the number of adult worms and a decrease in the number of inhibited forms of Ostertagia species during the seven days following the treatment. He suggested that the removal of adults had prompted the resumed development of inhibited forms. Dunsmore (1965), Brunsdon (1966), Soulsby (1966) and

Gibbs (1967), Blitz and Gibbs (1972b) tried fruitlessly to induce maturation of inhibited larvae in sheep during winter by administration of immunosuppressive drugs. Similarly Dunsmore (1965) and Connan (1968) stressed the importance of host endocrines in the maturation of inhibited larvae but felt a direct hormone-parasite interaction was unlikely.

According to Gibbs (1967) the maturation of inhibited larvae might be directly stimulated by changes in the host hormones, associated with the time of the year and the reproductive status of the sheep, and the high level of prolactin present in lactating ewes was felt to be of particular significance. He also observed that maturation of Haemonchus spp. extends over 2 months starting from April.

It was observed by Michel (1963) that the early L_4 of Ostertagia ostertagi did not accumulate in calves infected daily as long as the adults were regularly removed by anthelmintic treatment. As soon as this treatment was discontinued, and adult worms allowed to remain, inhibited forms quickly accumulated. Michel (1971) removed adult worm population of O. ostertagia in calves and found that their removal stimulated the resumed development of inhibited early L_4.

Evidence exist therefore, which suggest a connection between presence of adult worms and the resumption of development.

A transplant of inhibited larvae into helminth-free susceptible ewes was experimented by Blitz and Gibbs (1971b) during the winter but the larvae did not mature until the time the spring rise regularly took place. Both of them thought that the development of inhibited larvae in spring might occur spontaneously after the completion of certain physiological processes over the winter period, analogous to diapause development in dormant arthropods.

Blitz and Gibbs (1972b) found that majority of H. contortus in non-reproductive sheep between December and April were inhibited larvae. In May and June, they found all 3 phases of development i.e. adult, developmental and inhibited larvae in equal proportions. They concluded that maturation of inhibited larvae of H. contortus occurs spontaneously in spring.

Anthelmintic efficacy against inhibited larvae

Prichard (1973) indicated that the fumarate reductase system, which functions in the respiratory chain of many helminths, appears to be the site of action of broad spectrum anthelmintics especially the imidazole derivatives. This reductase system is said to be a particularly vulnerable point in the metabolism of nematodes, for chemotherapeutic

interference. In addition, it has been reported (Saz and Lesure, 1968; Putter, 1970; Corbett and Goose 1971) that the substituted phenols and salicylaniiide groups of anthelmintics cause their effects on heiminths by inhibiting the oxidative phosphorylation which is coupled with the fumarate reductase system. These factors may have accounted for the non-susceptibility of inhibited nematodc larvae to anthelmintic treatments since these larvae are metabolically inactive. Inhibited larvae have been described by many authors as being metabolically inactive hence the term hypobiosis (Gordon, 1970).

Reid et al., (1968) and Armour (1970) have indicated that inhibited larvae of O. ostertagi in cattle are not affected by any anthelmintic. This has been attributed to the physical inaccessibility of the larvae deep in the abomasal mucosa. The mucus cell hyperplasia present in such cases affords them added protection (Hotson 1967). There is the fact also that in the inhibited state, the metabolic processes of such larvae are virtually suspended and thus do not absorb the anthelmintics administered (Armour (1970).

Similar view has been held by Raynaud (1968) who found that the anthelmintic sensitivity of early L_4 of O. ostertagi in development is higher than that of inhibited larvae.

In sheep, variable anthelmintic activity has been reported against inhibited larvae of Ostertagia spp. and Haemonchus spp. using routine dosage rates (Brunsdson, 1964; Procter and Gibbs, 1968; Herweijer, 1969; Colglazier, Kates and Enzie, 1971a,b; Gordon, 1974; Armour Bairden and Reid 1975).

Gibson (1964) and Gordon (1964) tried the effect of Thiabendazole* at a dosage of 50 mg/kg. body weight and found this to be effective only in removing adult H. contortus and not the inhibited larvae.

At the recommended dosage level of 66 mg/kg body weight, Lyons, Drudge and Knapp (1967) found that Thiabendazole was 99% to 100% effective against normally developing immature H. contortus.

The periparturient treatment of ewes with Thiabendazole at the rate of 100 mg/kg body weight suppressed egg rise but failed to prevent completely the faecal shedding of nematode ova (Procter and Gibbs, 1968). Colglazier, et al. (1969) found that Levamisole** at a dosage level of 8 mg/kg body weight, was highly effective in removing inhibited larvae of H. contortus. The same authors in 1969 and 1970 reported that

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* 2 - (4 - thiazolyl) - benzimidazole

** 2,3,5,6 - tetra hydro-6-phenylimidazo (2,1-b) - thiazole

Thiabendazole administered at the same dose rate, was only 3% effective against inhibited larvae of H. contortus resistant to either 50 mg/kg Thiabendazole or 20 mg/kg Parbendazole***. Theodorides, Scott and Laderman (1970) showed that a threefold increase in dose rate of Benzimidazole anthelmintics resulted in a worm reduction of 94% and 99% respectively. The percentage of inhibited larvae removed was not indicated. Colglazier, et al. (1971a) and Kates, et al. (1971) using sheep with natural infections of H. contortus resistant to Parbendazole, found that larval stages were less susceptible than adults. The same authors recorded increasing efficacy at higher dose rates. It was reported by Connan (1973) that by increasing the minimum recommended dosage rate of 44 mg/kg Thiabendazole to 100 mg/kg. a high proportion of inhibited larvae was successfully removed. Gordon (1974) tried the action of disophenol (2,6-diiodo-4-nitrophenol) and reported that a single treatment of sheep with this anthelmintic was followed by a prolonged period of protection against the establishment of adult H. contortus but the drug had no apparent effect on the inhibited early L_4 larvae. According to Mckenna (1974a) in New Zealand, treatment of lambs with 50 mg/kg body weight of Thiabendazole was effective against adult H. contortus in proportion of

*** Methyl 5-butylbenzimidazol-2- ylcarbamate

97.3% and up to 49.3% against inhibited larvae while Levimisole at 8 mg/kg was 99.3% to 100% effective against the adults and 99.6% against inhibited larvae.

By administering Thiabendazole at a dosage of 55 to 75 mg/kg body weight, a high efficacy was obtained against adult and inhibited larvae of Ostertagia spp. The mean efficiency being 100%, 99.8% and 81.8% in November, January and March respectively (Armour et al., 1975).

Hematology in helminthiasis

Blood components, either erythrocytes or leucocytes and serum and its constituents have been examined countless times in many different helminth infections (Symons 1969). In most instances, any changes found probably indicate secondary responses to gastro-intestinal infection rather than the primary effect of the parasite on the host. Excluded from this comment must be the anaemias of hookworm infection and haemonchosis of ruminants which appear primarily due to blood loss by ingestion by the parasite.

Normal blood values are always altered to some extent by the influence of parasitism (Schalm, 1965).

Erythrocytes

Kates and Turner (1960) infected lambs with Trichostrongylus axei and found that in the acute phase, there was a relative erythrocythemia with hemoconcentration due to dehydration and in the chronic phase found oligocythemia due to failure of erythropoiesis, either toxic or dietetic in origin. Christie, Brambell and Charleston (1964) observed that there was a decline in haematocrit levels proportional to the adult H. contortus population. Experimental infection with H. contortus in sheep was carried out in Australia by Dineen et al. (1965). One group received three thousand larvae only once while another group received daily dose of one hundred larvae for 30 days. They found that after 2 months in the former group the packed cell volume was about 17% while in the latter, packed cell volume was about 20%. Horak and Clark (1964, 1966) examined the blood changes in sheep with O. circumcincta and O. columbianum and observed that in the former infection, there was an initial rise in packed cell volume and haemoglobin concentration in 3 sheep due to plasma volume shrinkage and to an increased absolute volume of erythrocytes. Subsequently, however, there was a fall in PCV, and Hb. values in most sheep. These and the changes in circulating plasma volume, the authors

believed were dietetic in origin.

Leucocytes

Many workers have examined the numbers of leucocytes in infections of hosts by helminths, but little functional conclusion can be drawn. Sometimes, leucocytosis was recorded, sometimes a leucopenia and sometimes no change was found. Variations in the severity of the infection and the timing of the examinations can explain some of these differences. One of the few more systematic experiments was that of Todd and Wyant (1951) who looked at the leucocytes in subclinical infections of sheep with Ostertagia spp. but used only 3 lambs. Two of these animals showed a progressive, but not constant, decrease in the number of white cells per milliliter on initial infection. This decrease was arrested and restored at the time of the sexual maturity of the parasites, but was later resumed. A severely affected lamb approached a neutrophilic leucopenia following a second exposure to the parasites, the total leucocytes and absolute lymphocytic and neutrophilic counts made moderate progressive increases.

Differential leucocyte

Eosinophilia is a phenomenon reported for a number of different infections but which does not appear to occur regularly, or persist at all stages of the disease. Its significance has not been established (Symons, 1969) but infections of the full range of parasitic groups have been involved. Gorshkov (1946) found an eosinophilia of 10.5 to 17% in horses infected with H. megastoma. A profound eosinophilia was found in man with trichostrongylosis (Wallace et al. 1956) and in guinea pigs with experimental infections of A. lumbricoides in the migratory phase (Belyaeva, 1966). This latter author examined the bone marrow and found a concurrent eosinophilic reaction in that tissue.

No eosinophilia was found by Stankiewicz (1964) in rabbits infected with S. papillosus while an eosinophilia was found in some cases only of sheep with oesophagostomiasis (Fourie, 1936) in sheep, Leland et al. (1960) found that infection with T. axei of a horse strain produced eosinophilia from 4 to 8 weeks which then dropped to normal limits.

There have been conflicting reports on the behaviour of lymphocytes in parasitic immunity (Dineen, 1967). Stankiewicz (1964) found an increase in the number of large lymphocytes and a decrease of small

lymphocytes in rabbits infected with S. papillosus. A lymphocytosis of up to 70% in horses with H. megastoma infection was reported by Gorshkov (1946) and no change in lymphocytes was recorded by El Hindawy (1948) in dogs infected with Toxascaris. Harness, Fitzsimmons and Sellwood (1970) having infected 3 groups of calves with 50,000, 125,000 and 500,000 infective larvae of H. placei, found that in the calves with higher level of infection, there was reduction in lymphocytes and neutrophils and also fluctuation in the number of monocytes but the number never exceeded 10% of total leukocyte count.

Plasma Proteins

There may be little or no detectable changes in total plasma proteins when there has been a fall in albumin and a rise in gamma globulin during several infections (Symons 1969). Mahrt et al. (1964) recorded a fall in serum albumin and a concurrent increase in gamma globulin in calves infected with O. ostertagi and a few Cooperia spp., but little change in total serum proteins. O. columbianum infection in sheep decreased the total plasma proteins with a decreased albumin and increased gamma globulin (Horak and Clark, 1966). Dobson (1965) found

similar changes and also observed that there was fall in alfa and beta globulins and a rise in beta 2 globulin. He reported that the serum albumin loss was as high as 1 gm% and was related to the dehydration caused by loss of water in the faeces. Fitzsimmons (1966) reported that T. colubriformis infection resulted in decreased serum proteins of the goat. Apart from the possible loss of albumin into the lumen of the intestine and its complete reabsorption, Cornelius et al. (1962) found that cattle with heavy infections of trichostrongylids had reduced synthesis of albumin, and that catabolism of this protein was increased in the terminal stages of infection. Leland et al. (1958) who found that total serum proteins were reduced in lambs with mixed trichostrongylid infections, suggested that liver function, and hence synthesis of plasma proteins, might be altered by malnutrition or by toxins from the parasites.

Anaemia

A functionally important aspect of haematological changes in helminth infection is the occurrence of anaemia. Fourie (1931) believed that the anaemia associated with Haemonchus spp. infection was due to haemorrhage. He found an early polycythemia followed by a failure of erythropoiesis and

a compensatory myeloid hyperplasia when the bone marrow became exhausted.

Delaune and Mayhew (1943) made a detailed haematological examination of cattle with haemonchosis and found that the erythrocytes began to decrease from days 5 to 7 after infection and that the haemoglobin concentration followed the same trend. This occurred during the prepatent period of the infection, after which the total erythrocyte and leukocyte counts as well as haemoglobin concentration rose towards and may exceed the normal levels. Lucker and Neumayer (1946) described the disease in lambs infected with B. trigonocephalum. In heavily infected lambs, they found occult blood in faeces and a normocytic, hypochromic anaemia with a depressed rate of growth. Romijin (1949) found that in strongyle infection, some horses had a distinct anaemia of the normocytic and normochromic type while a larger number showed morphological changes of the erythrocytes, especially microcytosis and spherocytosis.

Whitlock (1950) stated that H. contortus is the only parasite that can cause primary disease in sheep mainly by the extraction of blood and according to him, in order to draw meaningful conclusions from haematological examinations, it is important to ensure that technological factors are carefully controlled as well as to record as far as possible all details of heredity, diet, parasites, growth and metabolism. Gibson (1954a,b) found that lambs infected with T. axei on a low plane of

nutrition were anaemic while those on a high plane were not. He also stressed that this anaemia is unlikely to be caused by increased erythrocyte destruction but rather by haematopoietic disturbance initiated by nutritional deficiencies, resulting from reduced feed by infected animals coupled with excessive loss of metabolites into the gut via associated abomasal lesions. Similar views were held by Kates and Turner (1960).

It was suggested by Turner (1959) that the anaemia associated with S. papillosus infections is due to interference with the absorption of substances necessary for red cell synthesis.

Silverman and Patterson (1960) found that there was no response in sheep to the L_3, L_4 and L_5 histotrophic phases of larvae in either resistant or susceptible hosts until day 9 and that damage occured after day 10 when the young adults burrowed into the mucosa to suck blood.

Kiss (1961) considered that dogs with toxocariasis in which the erythrocyte count was reduced, the haemoglobin concentration in immature cells was 20 to 60% of normal, and anisocytosis and polychromasia were present, were suffering from a secondary toxic hypochromic anaemia.

Clark,Kiesel,and Goby (1962), found that the anaemia in haemonchosis is principally caused by the blood sucking activities of developing larvae and adults in the abomasum and each H.contortus causes an average blood loss of 0.049 ml per day, varying from 0.05

to 0.173 ml for individual sheep. A comparison of the blood and bone marrow of lambs with haemonchosis and those repeatedly bled was made by Charleston (1964). He reported a normochromic macrocytic anaemia in both bled and parasitized sheep, but he presented evidence of interference with normoblastic maturation and haemoglobination in the latter and so concluded that the anaemia caused by H.contortus differed from that of phlebotomy.

Georgi and Whitlock (1965) developed formulae to calculate the haemorrhagic stress and host response in sheep with haemonchosis and the erythrocytic restitution using ^{59}Fe, and blood sampling and the formulae could be used to calculate erythrocytic loss at a given time.

The anaemia associated with T.colubriformis infection may be caused by a toxin excreted by the parasite which may depress erythropoiesis (Horak et.al., 1968), Bremner (1969, 1970) showed that intestinal haemorrhage was the prime cause of anaemia in bovine oesophagostomiasis, and that neither intravascular haemolysis nor inhibition of erythropoiesis was involved.

Harness, et.al. (1970) infected 3 groups of calves with H.placei larvae at dosage levels of 50,000; 125,000 and 500,000. They found that in all the groups, reductions in packed cell volume and haemoglobin concentration were more marked in the calves with the higher levels of infection. Significant changes in red blood cells and white blood

cells occured only in calves infected with higher doses.

Misra and Ruprah (1972), found that with experimental Haemonchus spp. infection in lambs, there was decrease in the percentage of haemoglobin, packed cell volume, erythrocytes and leukocytes. An increase in the percentage of monocytes, neutrophils and to a lesser extent in eosinophils with a decrease in lymphocytes were also observed. On estimation of the mean corpuscular volume and mean corpuscular haemoglobin concentration per cent of the 2 groups (infected and control) it was observed that anaemia caused by H. contortus infection in lambs was microcytic and hypochromic.

Pradhan and Johnstone (1972) subjected a group of lambs to weekly dose of 3,500 infective larvae of H. contortus and another group to a daily dose of 500 larvae. After 8 weeks, they reduced the dosage levels to 1,400 and 200 larvae respectively. With the daily infection, a severe anaemia developed with 7% packed cell volume, 2% haemoglobin concentration and 1.6 m/mm^3 red blood cells at the 78th day. With the weekly dose, the anaemia was less severe with equivalent figures of 10,12% packed cell volume, 4% haemoglobin concentration and 3.6 m/mm^3 red blood cells. This haematological picture according to them confirmed the progressive development of severe anaemia which seems to be a critical

factor in the failure of the sheep to develop any strong resistance.

Pachalag, More and Chattopadhyay (1973) compared the blood values of 3 breeds of sheep in India under condition of helminthiasis and post drenching with Thiabendazole. They found that the percentage of red blood cells increased after drenching. Haemoglobin concentration improved and there was significant improvement in packed cell volume values. Prior to drenching, all animals had neutrophilia with relative lymphopenia.

Baker (1973) attributed the anaemia produced by T. colubriformis, to the inhibition of iron uptake and its reduced storage and transport resulting from changes in intestinal epithelial cells or loss of plasma transferrin to the gut.

Allonby and Urquhart (1975) carried out a study on merino sheep suffering from haemonchosis in East Africa. They found that moderate infections of a few hundred H. contortus persisted over a period of several months and these produced chronic anaemia. Mean PCV and Hb. values dropped progressively with increase in adult worm burden from 33% to 25% and 11 gm/dl to 7 g/dl respectively. Dargie and Allonby (1975) suggested that there are 3 stages in the development of anaemia in sheep suffering from haemonchosis. Stage 1 occurs in the first 3 weeks with progressive fall in PCV, negative or low egg count and normal

serum iron level.

The second stage may not initially involve a reduction in PCV but is accompanied by continuous abomasal haemorrhage caused by blood sucking developing stages, accompanied by a mass stimulation of erythropoiesis. The third stage is characterized by dramatic reduction in PCV and serum iron concentration showing exhaustion of the host's synthetic machinery due to deficiencies of iron and possibly available protein.

According to Holmes and Dargie (1975), heavy infection with Haemonchus spp. produces acute blood loss with macrocytic hypochromic anaemia. Intake of smaller number of larvae initially results in a normocytic normochromic type which later develops into macrocytosis and hypochromia.

A series of investigations on blood values of ruminants suffering from helminthiasis under Nigerian conditions have been carried out (Sprent, 1946, Fabiyi, 1968; Kuil, 1970 etc). Sprent (1946) described B. phlebotomum infections of zebu cattle to produce aplastic anaemia. According to Fabiyi (1968) a population of less than 250 adult Haemonchus spp. had no effect on the PCV and Hb concentration of goats. With increased number of helminths however PCV and Hb values

become lower.

Kuil (1970) who carried out studies in the Northern Guinea Savanna of Nigeria found that trichostrongyle infections in sheep were always associated with depriciation in blood values of the animals and that there was a positive correlation between the level of infection and level of deprecciation. The changes observed by him in infected animals were decreased PCV, Hb values and decreased serum proteins.

Oduye (1976) working with the Dwarf sheep of southern Nigeria, found lower PCV, Hb and RBC in chronic nematodiasis. Similar findings were made in Yankasa and Udah sheep in Zaria by Saror and Schillhorn (1977).

At the University Farm in Ibadan, Anosa (1977) observed that lambs 4 to 6½ months showed signs of severe parasitism including a normocytic normochromic anaemia characterized by low PCV, RBC and depressed Hb concentration. Anaemic lambs also showed marked reticulocytosis. Ewes were only mildly parasitized with low faecal egg counts and mild depression of red cell indices.

From all these analysis, it is quite evident that several blood changes do take place in animals during helminth infections and the degree of change depends on the number and species of helminths involved.

CHAPTER THREE

PASTURE INFECTIVITY IN THE NORTHERN GUINEA SAVANNA ZONE OF NIGERIA

INTRODUCTION

The climate of the northern Guinea savanna of Nigeria consists of a 6-month dry season and a 6-month rainy season i.e. November to April and May to October respectively. During the dry season, pastures dry up and the relative humidity falls as low as 13% in the mornings. Studies on the bionomics of trichostrongyles of sheep under these climatic conditions have been scanty.

Work by Sprent (1946) indicated that in the Vom area of northern Nigeria, the dry season was not suitable for the survival of the infective larvae of Bunostomum phlebotomum of cattle. Similarly, Lee, Armour and Ross (1960) noted that the conditions of the dry season in northern Nigeria were unsuitable for the survival of cattle trichostrongyle larvae on pasture.

In studies carried out in the Zaria area of northern Nigeria on goats, Fabiyi (1968) and on sheep Kuil (1970), concluded that survival

of trichostrongyle larvae was nil during the dry season and no infection could take place on pasture during this period.

Since planning of effective control measures is based on knowledge of the bionomics of larvae under local conditions, this experiment was designed to study the degree of pasture infectivity in the northern Guinea Savanna of Nigeria throughout a period of one year.

MATERIALS AND METHODS

Pasture:

In April 1976, an unimproved pasture of 2.5 hectares was acquired from the Ahmadu Bello University farm in Zaria. This was fenced with barbed wire to prevent introduction of unwanted animals. A covered shed of about 900 square feet was constructed inside the pasture to serve as shelter for experimental animals.

Pasture contamination:

In May of the same year, 64 naturally infected Yankasa ewes of between 2 to 4 years of age were introduced to contaminate the pasture which had been rendered helminth-free by the preceding dry season.

During the same week, 75 helminth-free Yankasa lambs of between 2-to 4 months of age were put on the pasture to graze with the infected ewes. The ewes and the lambs were later to be used for the study on larval inhibition (chapter 4).

Experimental lambs:

From the last week of June 1976, variable numbers of helminth-free tracer lambs were put on the contaminated pasture to graze for a period of 4 weeks following which they were withdrawn and housed under helminth-free conditions for 2 weeks before slaughter. The lambs were between 3 to 4 months old and were purchased from the Katsina emirate. Most of them were still breast-feeding at the time of purchase. They were ascertained as helminth-free by the fact that they were born during the dry season and had not been exposed to any pasture infection since none existed around them. Furthermore, examination of their faeces revealed no helminth eggs and no helminths were recovered from 3 of them that were killed to estimate worm burden. Each time the tracer lambs were removed from pasture, another group of helminth-free tracer lambs was introduced as replacement.

During the wet season, all animals had access to green vegetation with supplement of cotton seed/groundnut cake or cottonseed/guinea corn mixture. Commercial salt blocks and fresh water were provided ad libitum. During the dry season, they were fed hay and supplemented as above. A scheme of addition to and removal of tracer lambs from pasture is presented in table 3.

Laboratory analysis:

During the 4 weeks in which each group of lambs stayed on pasture and the 2 weeks in isolation, weekly faecal examination for helminth egg detection was done using the modified McMaster technique (Whitlock, 1948).

Necropsy:

After 2 weeks in isolation under helminth-free conditions, the lambs were slaughtered. The gastro-intestinal tract was recovered. The abomasum was opened and emptied into a graduated bucket. The mucosa was washed. The washings were added to the bucket and the volume

Table 3

Scheme of additions to and removal of tracer lambs from pasture for pasture infectivity studies.

Date		No. added to pasture	No. removed from pasture
June	1976	7	-
July	'76	5	5
August	'76	5	3
September	'76	6	3
October	'76	2	6
November	'76	2	2
December	'76	2	2
January	'77	2	2
February	'77	2	2
March	'77	2	2
April	'77	2	2
May	'77	2	2
June	'77	-	2
Total		39	33

made up to 3 liters. After stirring thoroughly, 2 samples of 30 ml. were drawn, and fixed with 5 ml. of 5% formalin. The same procedure was followed with the first 6 feet of the small intestine, the remaining part of the small intestine and the large intestine, except that from the whole content of the large intestine which was made up to 3 liters, only one sample of 150 ml. was taken.

The mucosa of the abomasum was scraped with an object slide and digested for 4 hours in hydrochloric acid/pepsin at 37°C. The digest was poured into graduated bucket and the volume made up to 3 liters with water. From this volume, samples of 30 ml. were drawn and fixed with 5 ml. of 5% formalin.

Worm recovery:

The samples of the stomach and intestines taken were sieved through a 63 micrometer sieve. The contents of the sieve containing the worms were washed into petri dish and stained with few drops of 5% iodine. The worms were counted and differentiated into their different genera using the 100 and 300 magnification of a dissecting microscope*.

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* Cycloptic stereoscopic microscope, Batelite Base model, America Optical Instrument, Buffalo, N.Y.

Weather data:

Weather data for the area in which the pasture was situated were compiled from the records of the Meteorological section of the Institute for Agricultural Research, Samaru. The monthly values are presented in table 4 and the daily values are presented in Appendix I.

RESULTS

Mean worm counts of the tracer lambs are presented in figure 1 and Table 5 while individual worm counts are presented in Appendix II.

Large numbers of trichostrongyle larvae were picked from pasture from June to October, as indicated by the number of helminths recovered from the animals. From November to January, the number of infective larvae decreased such that by the end of January, no more larvae remained infective on the pasture (fig.1). Pasture remained free of parasitic nematode from the end of January until the end of May. Infectivity of pasture resumed in June.

Large proportions of the H. contortus recovered in June and July were adults and developmental stages (late fourth stage larvae and fifth stage larvae) while from August to November, most of the larvae

Table 4

Comparative mean values of the weather records for June 1976 to June 1977

Month	Total rainfall (mm.)	Mean max. Temp. (°C)	Mean min. Temp. (°C)	Mean relative humid. at 10a.m. (%)	Mean ref. humid. at 4p.m. (%)	Mean soil Temp. at 2 in- (°C)	Mean soil Temp. at 1 ft. (°C)
June '76	206.9	29.5	19.5	75.3	62.7	26.6	26.3
July "	226.4	27.7	19.4	81.1	68.3	25.5	25.7
Aug. "	288.1	27.6	19.1	81.4	67.7	24.9	25.3
Sept. "	191.0	29.2	19.2	75.0	59.1	26.2	26.1
Oct. "	162.2	29.5	19.3	74.9	67.3	29.1	26.1
Nov. "	0	29.9	12.7	40.8	27.8	24.0	23.6
Dec. "	0	29.8	11.4	21.1	15.8	21.6	23.6
Jan. '77	0	29.4	12.7	20.0	20.0	22.1	22.1
Feb. "	0	30.6	14.0	13.5	10.0	23.1	23.2
Mar. "	0	33.3	18.9	15.8	11.7	26.6	25.5
Apr. "	0	36.8	14.4	26.6	13.9	32.3	29.1
May "	78.3	34.3	21.3	21.3	57.9	31.5	29.5
June "	102.0	30.7	20.3	74.2	58.8	28.2	27.2

picked up went into inhibited development. From June to November, high numbers of adult Trichostrongylus spp. were recovered from the animals. Very few number of Trichostrongylus spp. went into inhibited development. Inhibited larvae are those which after 4 days of post infection still remain with no apparent differentiation of the genital primordium and also contain conspicuous rod-like crystals within their intestinal cells.

Worms recovered in order of frequency were T. colubriformis, H. contortus, S. papillosus, O. columbianum, T. axei, Cooperia spp. and I. nudicollis.

Fig. I Rainfall, Relative humidity and soil temperature in relation to pasture infectivity within a 12-month period in the northern Guinea Savanna of Nigeria.

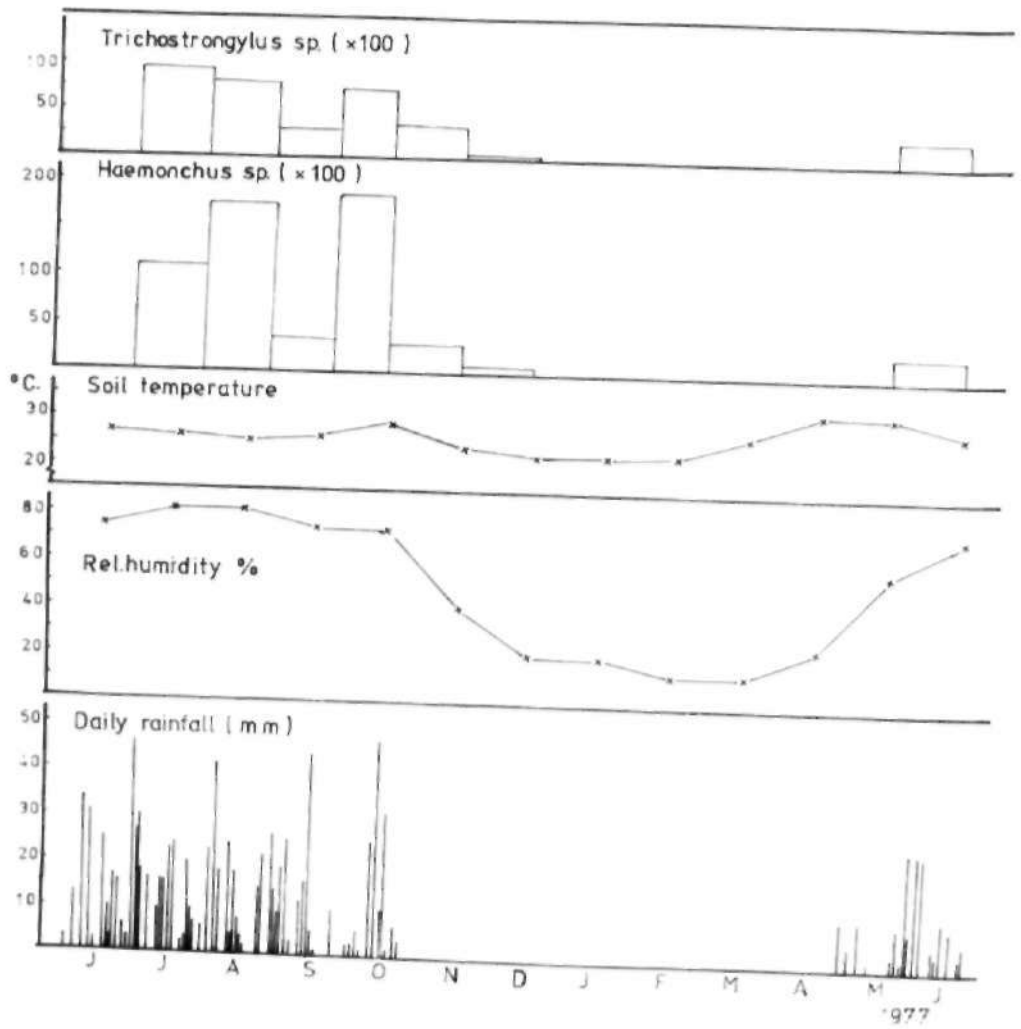

Trichostrongylus sp. (×100)
100
50
Haemonchus sp. (× 100)
200
100
50
°C.
Soil temperature
30
20
80
60
40
20
Rel.humidity %
50
40
30
20
10
Daily rainfall (mm)
J J A S O N D J F M A M J
1977

Table 5

Mean worm counts of helminth-free tracer lambs which were kept for one month per group on pasture through a period of twelve months.

Period sheep stayed on pasture		Haemonchus contortus		Trichostrongylus spp.		Cooperia spp.	Impalaia nudico-llis	Oesophagostumum columbianum (L4)	Strongy-loides papillosus
		Adult	immature stages	Adult	immature stages				
July	'76	2380	8240	7280	2360	0	0	26	180
August	'76	200	14825	5100	3150	25	25	150	125
September	'76	360	2370	2540	780	0	0	60	10
October	'76	470	17950	4960	2420	40	0	48	600
November	'76	20	2900	2850	650	0	0	200	0
December	'76	0	700	250	100	0	0	0	0
January	'77	0	0	0	0	0	0	0	0
February	'77	0	0	0	0	0	0	0	0
March	'77	0	0	0	0	0	0	0	0
April	'77	0	0	0	0	0	0	0	0
May	'77	0	0	0	0	0	0	0	0
June	'77	900	1600	2050	750	0	0	0	200

that the number of adult helminths in the host declined at the end of the rainy season and onwards into the dry season. At the end of the dry season, just before the rains start, there is an increase in the numbers of adult Haemonchus spp., Trichostrongylus spp., Cooperia spp., and Oesophagostomum spp. in ruminants. The subsequent rise in faecal egg counts has been demonstrated by Fabiyi (1973) and Van Geldorp and Schillhorn (1976). Hart (1964) working with cattle, demonstrated that the increase in adult helminth population at the end of the dry season was related to the resumed development of larvae which were inhibited at the beginning of that season. Inhibition is probably a major factor in the epidemiology of gastrointestinal helminthiasis in this country. The following trials were carried out to prove the occurrence of inhibited development of trichostrongyles under the conditions of the northern guinea savanna of Nigeria. The time of its induction and termination and the species of helminths involved were also investigated.

MATERIALS and METHODS

Pasture:

The pasture used in these trials and the method of getting the

pasture contaminated were the same as described in chapter 3.

Experimental animals:

Three groups of sheep were utilized, namely ewes, helminth-free lambs that were introduced to pasture and grazed continuously for the duration of this study (permanent lambs) and helminth-free tracer lambs which were put on pasture in groups to graze for only 4 weeks and then withdrawn for slaughter. Initially, the study started with the 64 ewes and 75 permanent lambs which were put on pasture in May 1976 and the helminth-free tracer lambs were the same animals used in the trials on pasture infectivity (chapter 3). At the end of every 4 weeks when the tracer lambs were withdrawn from pasture, variable numbers of ewes and permanent lambs were also withdrawn and a fresh group of tracer lambs put back on pasture. A scheme of withdrawal of ewes, permanent lambs and tracer lambs from pasture and addition of tracer lambs onto pasture is presented in table 6. In certain cases, the numbers of tracer lambs withdrawn from pasture were less than the numbers put on pasture. This was due to the fact that some of them died on pasture within that grazing period of 4 weeks.

By the end of December 1976, a total of 35 ewes and 33 permanent lambs had been withdrawn from the pasture and evaluated for presence of inhibited

Table 6

Scheme of withdrawals from and additions of sheep to pasture for inhibition studies

		Withdrawn			
		Ewes	Permanent lambs	Tracer lambs	Worm-free tracer lambs added
June	1976	5	5	-	7
July	"	5	5	5	5
August	"	5	6	3	5
September	"	6	5	3	6
October	"	5	4	6	2
November	"	5	5	2	2
December	"	4	3	2	2
January	1977	4	4	2	2
February	"	4	3	2	2
March	"	4	4	2	2
April	"	6	4	2	2
May	"	4	4	2	2
June	"	4	4	2	-
Total		61	56	33	39

larvae. During the same period, 23 ewes and 38 permanent lambs died on pasture mainly due to helminthiasis. Thus at the end of December 1976, there remained only 6 ewes and 4 permanent lambs on pasture.

In January 1977, 40 additional sheep were purchased from the University farm and introduced on pasture. These comprised of 10 ewes and 30 lambs. The sheep purchased from the University Farm had similar grazing history as those on the experimental pasture. Thus at the beginning of January 1977, there were 16 ewes and 34 permanent lambs on trial on pasture. From January to the end of March 1977, 12 ewes and 11 permanent lambs had again been withdrawn from pasture to evaluate the presence of inhibited larvae. During this period, 9 permanent lambs died on pasture. An additional 120 ewes were purchased at the end of March 1977 from the Zaria area and introduced to the pasture. 10 of these ewes were added to those 4 left from the previous batch and used to complete the inhibition study. The remaining 110 were later used for anthelmintic trials (chapter V). Between April and June 1977, 14 ewes and 12 permanent lambs were withdrawn from pasture. Two permanent lambs died on pasture during the same period.

The management of the animals while on pasture, necropsy, worm recovery and worm identification procedures were the same as described in chapter 3.

Inhibited larval forms of helminths were identified by the presence in them of rodlike crystals and the absence of genital primodium as originally described by Blitz and Gibbs (1971b).

A second experiment was conducted to compare the inhibition pattern of sheep from Katsina and Zaria areas. For this study, two Yankasa lambs 7 months old were purchased from the University Farm in August 1976 and housed under helminth-free conditions for 2 weeks after which they were slaughtered and worm counts made using the method previously described.

In a third trial carried out in October 1976, the purpose of which was to determine whether larvae which have not been exposed to pasture conditions could also go into inhibition, two helminth-free lambs were experimentally infected each with 17400 infective trichostrongylid larvae containing 92% H. contortus larvae. The larvae were obtained from a faeces/vermiculite culture which had been incubated for 7 days at 27°C. The lambs were slaughtered two weeks after infection. Necropsy, worm recovery, counts and identification of inhibited larvae were carried out as previously described.

As a control for this third trial, a non-infected lamb with the same history as the two above, was slaughtered one day after necropsy of the two and examined for the presence of worms.

Post mortem examinations were performed on all the sheep which died on pasture and worm counts made following the procedure already described. During the study, a total of 78 sheep died on pasture. Out of this number, 23 were ewes, 49 were permanent lambs and 6 were tracer lambs. Findings at necropsy showed that 23 of the sheep (mostly lambs) died of acute helminth infection, 25 of chronic helminth infection, 20 of a mixture of helminth and heavy coccidial infection, 4 of heartwater infection and 6 of bloat.

The accumulated data were analysed by computer*.

RESULTS

The results of this study are summarized in Fig. 2-4 and Tables 7-10. Worm counts of individual sheep are presented in Appendix III. Analysis of variance tables for the different developmental stages of Haemonchus spp. and Trichostrongylus spp. in the 3 groups of sheep used are presented in Appendix IV.

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* Control Data Computer Cyber 72, Model 13, operating system numbers 1.1.0. 430B

From August to March, the number of adult Haemonchus spp. decreased progressively. Very few developmental stages were recovered while the number of inhibited larvae increased. From April to July, the number of inhibited L_4 decreased while adults and developmental stages increased sharply. The 3 stages of development were recovered in high proportions during July and August (Table 7).

The picture was however different for Trichostrongylus spp. From June to June, adult forms were found in high numbers. Similarly, developmental stages were recovered throughout the year although in very low numbers. The numbers of inhibited L_3 were very low from April to June and high from July to March (Table 8).

From January to May, tracer lambs did not pick up any infection from pasture. Inhibited larvae were recorded for only Haemonchus spp. and Trichostrongylus spp. Other nematodes recovered from the sheep were Strongyloides papillosus, Cooperia spp., Impalaia nudicollis, Gaigeria pachyscelis, and Oesophagostomum columbianum but none of them had the inhibited larval form.

Haemonchus spp go into inhibition at the early larva four (HL_4) stage while Trichostrongylus spp. get inhibited at larva three (L_3) stage. The number of inhibited Trichostrongylus spp larvae was very low compared with that of Haemonchus spp.

In the 3 groups of sheep used in this study i.e ewes, lambs which grazed permanently and tracer lambs, there were no significant differences between the groups in the numbers of inhibited Haemonchus spp ($P>0.5$), developmental Haemonchus spp. ($P>0.2$), inhibited Trichostrongylus spp. ($P>.05$) and developmental Trichostrongylus spp ($P>.05$) but there were highly significant differences in the number of adult Haemonchus spp ($P<.01$) and adult Trichostrongylus spp. ($P<.01$). These are summarized in appendix IV.

In the second trial (Table 9), more than 63% of the Haemonchus spp. recovered from the University Farm lambs were recovered as inhibited larvae. The percentage adult of the same species of helminths in the 2 lambs during the period they were necropsied was zero and 15.3%. The percentage of developmental stages during this period was between 21.2% and 35.7%.

The number of inhibited Trichostrongylus spp. recovered from the 2 lambs was low (0.8 and 3.4%), but adult forms were recovered in high numbers (93 and 96.7%).

Like in trial 1, inhibited larvae were only found in Haemonchus spp. and Trichostrongylus spp. and at EL_4 and L_3 stages respectively. In the third trial (table 10), of the 2 lambs given 17,400 infective

trichostrongylid larvae each, 2550 Haemonchus spp and 600 Trichostrongylus spp. were recovered from one of them. 96% of the 2550 Haemonchus spp. were recovered as inhibited EL_4 while none of the 600 Trichostrongylus spp. was inhibited larva. Out of the 9600 Haemonchus spp. recovered from the second lamb, 99% of this number were recovered as inhibited larvae. Similarly, no inhibited Trichostrongylus spp larvae were recovered.

Fig. 2: Pattern of inhibited development of trichostrongyle larvae in ewes.

+————————+ = Adult Trichostrongylus spp.

x————————x = Inhibited Trichostrongylus larvae

o————————o = Inhibited Haemonchus larvae

.————————. = Adult Haemonchus spp.

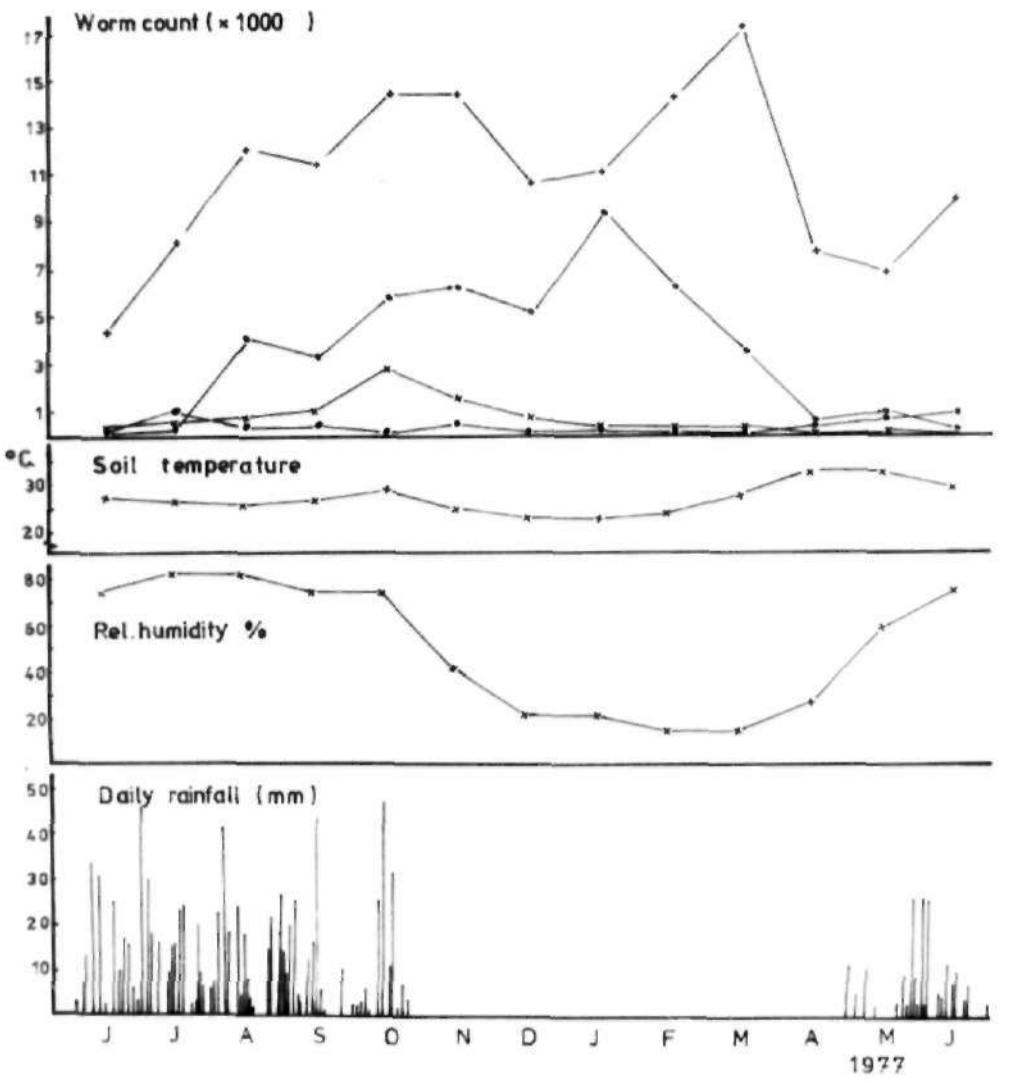

Worm count (× 1000)
17
15
13
11
9
7
5
3
1
°C.
Soil temperature
30
20
80
60
40
20
Rel. humidity %
50
40
30
20
10
Daily rainfall (mm)
J J A S O N D J F M A M J
1977

Fig. 3: Pattern of inhibited development of trichostrongyle larvae in lambs that grazed continuously on pasture.

+————————+ = Adult Trichostrongylus spp.

x————————x = Inhibited Trichostrongylus larvae

o————————o = Inhibited Haemonchus larvae

.————————. = Adult Haemonchus spp.

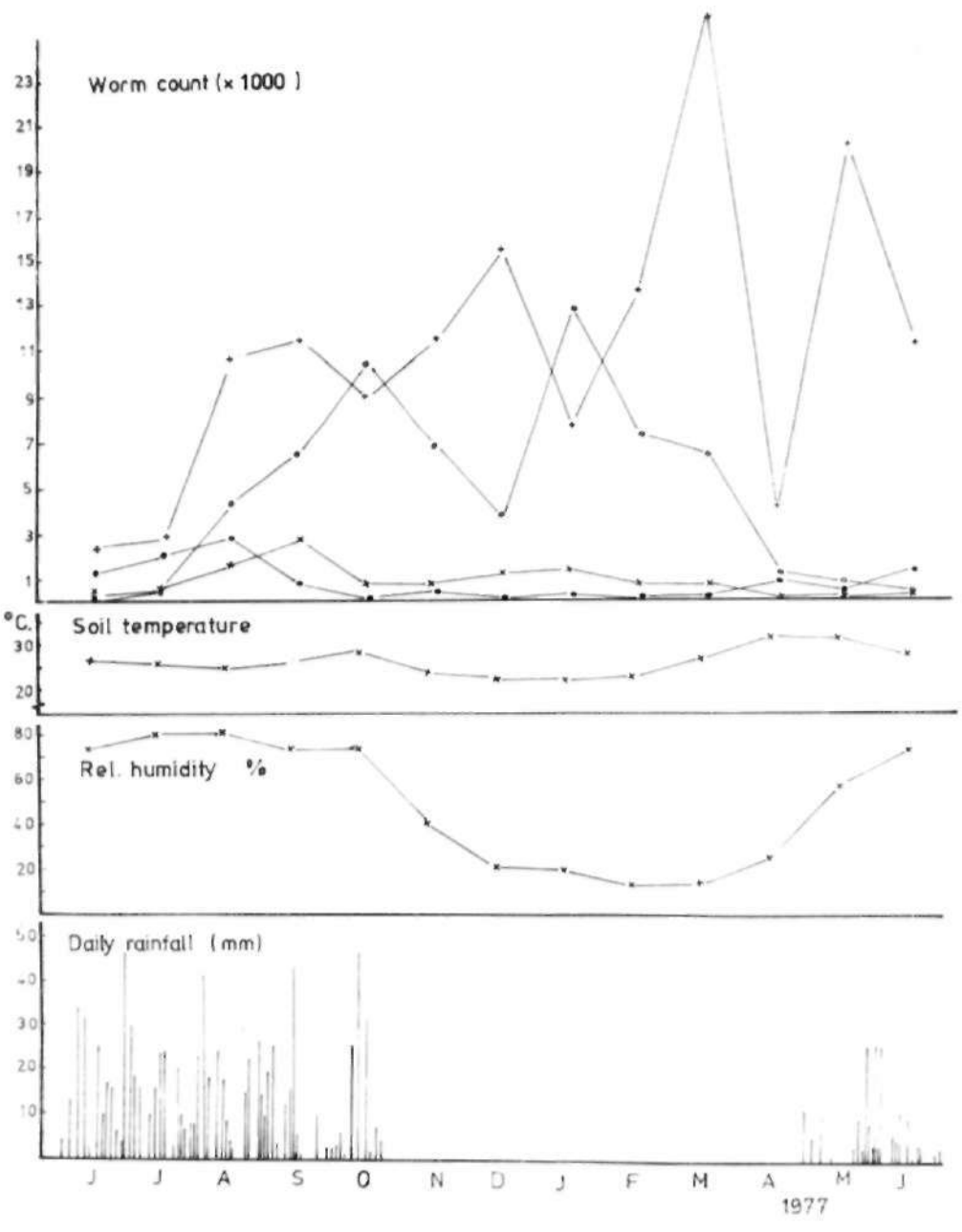

Worm count (× 1000)
23
21
19
17
15
13
11
9
7
5
3
1
°C.
30
20
Soil temperature
80
60
40
20
Rel. humidity %
50
40
30
20
10
Daily rainfall (mm)
J J A S O N D J F M A M J
1977

Fig. 4: Pattern of inhibited development of trichostrongyle larvae in groups of tracer lambs that grazed for 4 weeks per group on pasture.

o----------o = Haemonchus inhibited larvae

.----------. = Haemonchus adults

x----------x = Trichostrongylus inhibited larvae

+----------+ = Trichostrongylus adults

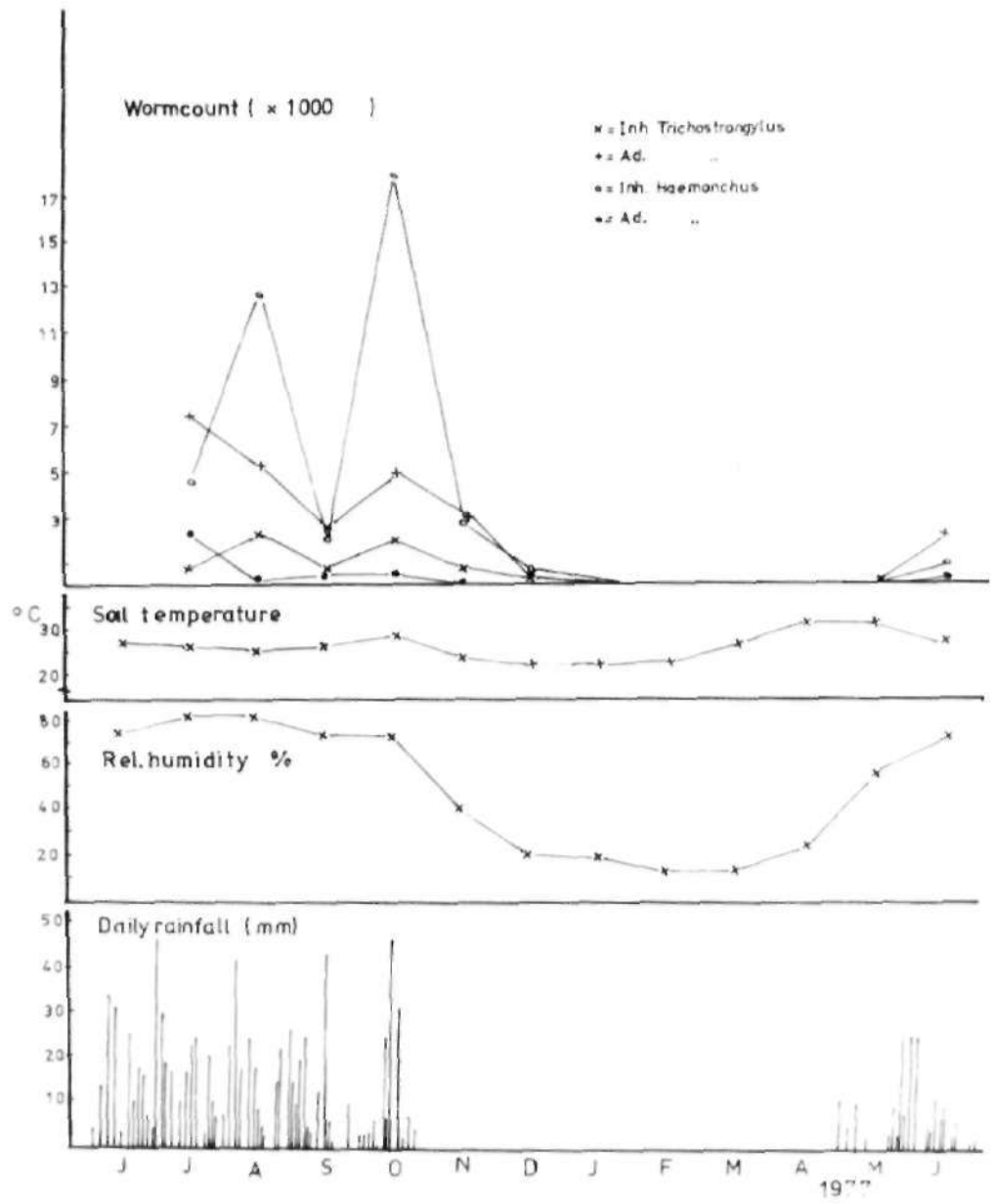

Wormcount (× 1000)
× = Inh. Trichostrongylus
+ = Ad. ..
• = Inh. Haemonchus
•₂ Ad. ..
17
15
13
11
9
7
5
3
°C
30
20
Soil temperature
80
60
40
20
Rel. humidity %
50
40
30
20
10
Daily rainfall (mm)
J J A S O N D J F M A M J
1977

Table 7

Mean and standard deviation of Haemonchus spp recovered from sheep which were withdrawn from pasture at various times of the year and housed for 2 weeks under worm-free conditions before slaughter.

Time sheep withdrawn from pasture	Ewes			Permanent lambs			Tracer lambs		
	Adult	Dev. stages	EL_4	Adult	Dev. stages	EL_4	Adult	Dev. stages	EL_4
June 1976	120±138.0	445± 576.2	20± 21.0	1199± 1544.5	1101 ±1535.0	52 ±53.0	-	-	-
July 1976	1113± 1311.7	1975± 1532.0	312± 433.0	2020± 1303.2	2460± 3374.0	580± 844.0	2380± 1480.5	3600± 2611.0	4640± 3658
August 1976	580± 438.2	940± 581.0	4120± 2283.0	2760± 1585.0	2140± 2761.0	4220± 2434.0	200± 182.6	2625± 2251.0	12200± 8760.0
September 1976	508± 898.0	1050± 1894.0	3583± 2987.0	920± 1351.0	100± 173.0	6570± 5298.0	360± 568.0	280± 217.0	2090± 1025.0
October 1976	120± 164.3	80± 130.0	5930± 2775.0	175± 170.7	225± 206.0	10225± 4092.0	392± 429.4	100± 167.0	14858± 6482.0
November 1976	680± 875.8	0	7540± 3177.0	420± 311.4	0	6860± 2867.0	20± 28.3	0	2900± 424.0
December 1976	25±50.0	0	5275± 2578.0	133.3± 230.9	0	3633± 2182.0	0	0	700± 283.0
January 1977	175±206.2	0	9425± 3906.0	375± 150.0	25±50.0	12750± 6614.0	0	0	0

Table 7 (Continued)

Time sheep withdrawn from pasture	Ewes			Permanent lambs			Tracer lambs		
	Adult	Dev. stages	EL_4	Adult	Dev. stages	EL_4	Adult	Dev. stages	EL_4
February 1977	50±57.7	0	6475± 3971.0	133.3 115.5	0	7233± 4450.0	0	0	0
March 1977	100 ±141	0	5175 ± ±2550.0	275 ±205.4	50± 100.0	61525 ±2043.0	0	0	0
April 1977	375 ±379.0	650 ±602.5	683± 571.0	850± 341.6	1500 ±182.6	1175 ±591.0	0	0	0
May 1977	825 ±170.8	850 ±208.0	1075± 1294.0	625± 359.4	925± 95.7	750± 387.0	0	0	0
June 1977	1025 ±170.8	1725 ±309.6	250± 129.0	1400± 454.6	2300± 408.0	450± 351.0	900± 141.0	1550± 494.9	50± 71.0

Table 8

Mean and standard deviation of Trichostrongylus spp. recovered from sheep which were withdrawn from pasture at various times of the year and housed for 2 weeks under worm-free conditions before slaughter.

Time sheep withdrawn from pasture	Ewes			Permanent lambs			Tracer lambs		
	Adult	Dev. stages	L_3	Adult	Dev. stages	L_3	Adult	Dev. stages	L_3
June 1976	4510± 4431	45± 51.2	365± 141	2489± 2927	64.6± 91.3	157± 222	-	-	-
July 1976	9212± 10604	120± 138	600± 178	2840± 1750	340± 607	420± 668	7280± 4215	1620± 835	740± 498
August 1976	12080± 6595	200± 141	960± 750	10660± 1845	940± 1172	1580± 1865	5100± 4838	1075± 1253	2075± 2485
September 1976	11433± 3841	483± 538	1192± 1073	11450± 4395	80± 109.5	2720± 3177	2540± 2734	460± 422	280± 217
October 1976	14560± 5568	240± 288	2920± 4149	5850± 4992	0	975± 1466	4133± 631	516.6± 449	1500± 1263
November 1976	14520± 13035	400± 515	1600± 2969	11260± 2839	400± 212	820± 712	2850± 495	0	650± 212
December 1976	10775± 10553	0	400± 566	15333± 4509	266.6± 462	1200± 700	250± 71	0	50±70.7
January 1977	11175± 10003	0	425± 403	7750± 1808	0	1425± 1144	0	0	0

Table 8 (Continued)

Time sheep withdrawn from pasture	Ewes			Permanent lambs			Tracer lambs		
	Adult	Dev. stages	L_3	Adult	Dev. stages	L_3	Adult	Dev. stages	L_3
February 1977	14275± 11753	0	275± 340	135± 5603	133.3± 231	833± 551	0	0	0
March 1977	21600± 15615	50± 100	300± 316	25725± 21332	100± 200	675± 359	0	0	0
April 1977	7900± 5391	291.6± 390	75± 117	4050± 2674	600± 391	100± 141	0	0	0
May 1977	7050± 4900	450± 129	125± 189	19750± 7974	774± 171	100± 115	0	0	0
June 1977	10100± 9290	1175± 359	100± 141	7325± 9200	2600± 920	225± 263	2050± 777.8	700± 707	50± 71

Table 9

Differential worm counts of two lambs from the University Farm isolated from pasture on August 24, 1976 and killed 14 days later

Haemonchus contortus				*Trichostrongylus* Spp.			
Numbers Found	Percentage Adults	Percentage Develop. stages	Percentage Inhibited Early L_4	Numbers Found	Percentage Adults	Percentage Develop. stages	Percentage inhibited L_3
5200	15.3	21.2	63.5	8700	93.2	3.	3.4
700	0	35.7	64.3	6050	96.7	2.5	0.8

Table 10

Differential worm counts of lambs in trial 3, killed 14 days after experimental infection with infective trichostrongylid larvae.

	Haemonchus contortus		Trichostrongylus spp		Strongyloides papillosus
No. L_3 inoculated	Numbers found	Percentage inhibited early L_4	Numbers found	Percentage inhibited L_3	Number found
1. 17400	2550	96	600	0	500
2. 17400	9600	99	600	0	0
Control o	o	o	o	o	367

Discussion

In this study, under the conditions of the Northern Guinea savanna, it is found that only the larvae of Haemonchus spp and Trichostrongylus spp. are capable of undergoing inhibited development and at the early fourth stage and third stage respectively. Inhibition in the third stage has been described for Trichostrongylus retortaeformis in the rabbit (Michel, 1952) and T. axei, T. vitrinus and T. colubriformis in sheep in the Netherlands (Eysker, 1978). Muller (1968) described inhibited L_5 of Trichostrongylus spp from sheep while Reid and Armour (1972) and Ayalew, Frechette, Malo and Beauregard (1973) described inhibition of Trichostrongylus spp at early L_4 stage. It may be concluded then that the stage of development at which Trichostrongylus spp go into inhibition varies with the ecological zone.

A large number of the Haemonchus spp larvae which were picked up from pasture as from August went into inhibition instead of developing normally. This is evidenced by the increase in number of inhibited larvae and corresponding decrease in the numbers of adult and developmental stages obtained from August to March. By August, the rainy season was getting to an end and the extremely unfavourable dry season would soon set in. It is most probable that during this period, an

environmental stimulus acted on the preparasitic stages of the helminths and this stimulus programmed the larvae for inhibited development as postulated by Connan (1975).

It was found that from April to July, the number of inhibited larvae decreased while adults and developmental stages increased in number. April is the end of a 6-month long dry season, a period during which conditions on pasture were too dry to permit larval development. The increase in the number of adults and developmental stages of Haemonchus spp from April therefore could only have resulted from an augmentation of the existing number from inhibited larvae which were now coming out of inhibition and undergoing their normal development. It is noted that during this period, there was a decrease in the number of inhibited larvae. This result confirms the observations of Hart (1964) and Van Geldorp and Schillhorn (1976) that parasitic stages of some trichostrongyles which have otherwise inhibited their development in the host, resume their development at the beginning of the rainy season, augmenting the existing adult population.

The level of inhibited development in Trichostrongylus spp. was very low and adult forms were recovered in high numbers throughout the year. As could be seen in the worm counts of the tracer lambs, no infection was acquired on pasture from January to May due to lack of

moisture. The results obtained here then confirm those of Kuil (1970) that Trichostrongylus spp. are capable of surviving unfavourable conditions of the environment as adults in the host.

The level of inhibited development in the ewes which have grazed for a number of years and have as such developed some immune resistance to trichostrongyles did not differ significantly from the level in the lambs that were coming to pasture for the first season and as such had not built up any immune resistance. This finding lends support to the hypothesis of Blitz and Gibbs (1971a) that arrested development of Haemonchus spp. during winter and subsequent maturation in the spring (the 2 periods are equivalents of the dry season and the beginning of the rainy season respectively under Nigerian conditions), are integral part of the life cycle of the helminth regulated by the helminth itself and not by immune status.

The helminth population of the 2 lambs from the University Farm (trial 2) showed no principal differences with the helminth populations of the sheep from trial 1 which were isolated from pasture in August 1976. Only Haemonchus spp and Trichostrongylus spp had inhibited larvae. The high percentage of inhibited Haemonchus spp larvae with the corresponding decrease in the number of adult forms indicate the entry of larvae into

inhibition. The presence of a reasonably high percentage of developmental stages (Late L_4 and early L_5) indicated that despite the fact that many of the larvae picked up on pasture went into inhibited development, many still continued to develop normally in August. Also in trial 2, inhibited L_3 of Trichostrongylus spp. were recovered in low numbers, while the percentage of adult forms was high. From the foregoing facts, it is clear that there is no difference in the pattern of inhibition in sheep from the Sudan zone and the Guinea savanna zone of Nigeria. Climatically, there is not much difference in these 2 zones except for a fairly longer dry season and shorter rainy season in the former. In trial 3, a very high level of inhibition of H. contortus occured in 2 young lambs infected experimentally in October with infective larvae cultured in the laboratory for 7 days at 27°C. Connan (1975) carried out similar experiment and concluded that inhibition under this condition was brought about primarily by environmental stimulus. The present results can be explained in the same way but the nature of the environmental stimulus which is involved in the 7 day period is not clear. Alternatively, some factors in the donor or the recipient host may be responsible for the high levels of inhibition seen in trial 3. Still another possibility is that no environmental stimuli are necessary. This would implicate an

obligatory inhibition of H. contortus at the end of the rainy season independent from host and environmental factors.

CONCLUSIONS

From the results of this study, it is concluded that in the northern part of Nigeria (1) The phenomenon of larval inhibition of sheep trichostrongyles does exist.

(2) Only the larvae of Haemonchus spp and Trichostrongylus spp are capable of undergoing inhibited development.

(3) Haemonchus spp get inhibited at the early fourth stage (EL_4) while Trichostrongylus species at third stage (L_3).

(4) Going into inhibition is at its highest in August which is near to the end of the rains.

(5) The larvae come out of inhibition as from April which is the end of the dry season.

(6) Haemonchus spp are more inhibition-prone than Trichostrongylus spp. This is due to the fact that Trichostrongylus spp can very well survive the period of environmental adversity as adults in the host but Haemonchus spp cannot.

(7) There is no difference in the inhibition pattern of sheep from the Sudan zone and the Northern Guinea savanna zone of Nigeria.

(8) Infective larvae cultured in the laboratory go equally into inhibition as larvae picked up from pasture. This weakens the argument in favour of environmental stimuli on pasture as a major cause of inhibited development.

(9) Level of inhibition in immuned ewes did not differ significantly from the level in non-immuned lambs. This also indicates that immunity of the host is not a major determinant of inhibited development.

CHAPTER FIVE

ANTHELMINTIC EFFICACY AGAINST INHIBITED LARVAE

INTRODUCTION

Larval forms of certain gastro-intestinal trichostrongyles arrest their development in the hosts in order to survive the external adverse weather conditions.

In Nigeria, inhibited development of Haemonchus spp. occurs mainly in the dry season. The larvae resume their development just before the onset of the rains. The result is that pastures are heavily polluted early in the rains and massive infestation of stock occurs.

Inhibited larvae of Haemonchus spp. are superficially embedded in the abomasal mucosa and are metabolically inactive (Gordon, 1970). This explains why all currently known anthelmintics at the conventional dosage levels do not affect the inhibited larvae. Some drugs have, however, been reported to have some efficacy at increased dosages (Procter and Gibbs, 1968; Colglazier, et al., 1969; Connan, 1973).

Some of the currently used veterinary anthelmintics on Nigerian market are Thiabendazole[(a)], Ranide[(b)] and Loxon 2[(c)]. Nemafax[(d)] is a new addition and according to the manufacturers, it has a wide spectrum of activity. Of all these drugs, Thiabendazole has been longest on Nigerian market and investigations in overseas countries have confirmed its efficacy at increased dosage levels against inhibited trichostrongyle larvae (Connan, 1973; Mckenna, 1974a and Armour et al., 1975).

The purpose of this study was to test these drugs on sheep under Nigerian conditions, determine their efficacy and at what dosage levels against the inhibited larvae of Haemonchus spp. and Trichostrongylus spp.

MATERIALS and METHODS

Two trials were carried out. Trial I was carried out during the dry season (April 1977) while trial II was carried out during the rainy season (August 1977). The animals utilized in trial I consisted of 42 out of the

(a) Thiabendazole = (2-(4-thiazolyl)-benzimidazole). MSD

(b) Ranide = 3'-chloro-4'-(p-chlorophenoxy)-3,5 diiodo-salicylanilide MSD

(c) Loxon 2 = O,O-di(2-chloroethyl), O-(3-chloro,4-methyl, 7 coumarinyl) phosphate. Cooper

(d) Nemafax = (1,2-bis(3-ethoxycarbonyl-2-thioureido)-benzene). M&B

110 Yankasa ewes earmarked on pasture in March 1977 for drug trials as described in chapter 4. The 42 ewes were divided into 6 experimental groups and one control group. Each group consisted of 6 ewes. 3 groups of ewes received Nemafax at dose rate of 50 mg/kg. body weight, 100 mg./kg body weight and 200 mg./kg. body weight. 3 other groups received Thiabendazole at the same dose rates. The control group received no treatment (Table 11). Both drugs were prepared as suspension and administered orally by drenching.* Management of the ewes was same as described in chapter 3.

Following treatment, the animals were isolated under helminth-free conditions for 2 weeks before slaughter. Faecal and blood samples of all animals were evaluated 2 weeks before and after treatment. Faecal egg counts were performed using the MacMaster technique (Whitlock, 1948), while blood samples were evaluated for red cells and white cells, using an electronic counter+. Packed cell volume was determined using the microhaematocrit centrifuge** and haemoglobin was determined by the cyanmethaemoglobin method+.

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* Phillips automatic drencher, Model MK III, N.J Phillips Ltd., Sydney, Australia.

** Microhaematocrit centrifuge. Hawksley, England.

\+ Coulter Electronics, Inc. Hialeah, Florida, U.S.A.

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Table 11

Scheme of anthelmintic treatment of sheep in trial 1 using Nemafax and Thiabendazole

Drug	50 mg/kg	100 mg/kg	200 mg/kg	Untreated
Nemafax	6	6	6	0
Thiabendazole	6	6	6	0
Controls	0	0	0	6

Body weights were determined just prior to treatment and just before slaughter. Following slaughter of the ewes, worm counts and identification of adult and larval forms were performed as previously described in chapter 3.

Inhibited trichostrongylid larvae were differentiated from normally developing larval forms by the established criteria of Blitz and Gibbs (1971b). By the time trial II was carried out in August 1977, only 50 out of the remaining 68 ewes were alive on pasture, the rest having died of helminthiasis. Out of these 50 ewes, 3 were isolated under helminth-free conditions for 2 weeks and then slaughtered to determine the presence of inhibited larvae. After the presence of inhibited larvae has been proved in the 3 ewes, 46 of the remaining 47 ewes were then withdrawn from pasture and housed under helminth-free conditions for 2 weeks. Management of the ewes was as previously described in chapter 4. After 2 weeks of isolation, the ewes were separated into 9 groups and drenched orally with varying doses of Nemafax, Thiabendazole, Ranide and Loxon 2 according to the scheme presented in table 12. The ewes were slaughtered a week after drenching and examined for the presence of worms and inhibited larvae as described for trial I. All laboratory procedures were similar to those described for trial I.

Table 12

Scheme of anthelmintic treatment of sheep in trial 2

	50 mg/kg	100 mg/kg	7.58 mg/kg	25.5 mg/kg	15.16 mg/kg	51mg/kg	Untreated
Loxon 2	0	0	0	6	0	6	0
Ranide	0	0	6	0	6	0	0
Thiabendazole	4	4	0	0	0	0	0
Nemafax	4	4	0	0	0	0	0
Control	0	0	0	0	0	0	6

RESULTS

Means and standard deviation of values obtained from trials I and II are presented in Tables 13 to 18. Individual results are presented in appendix V.

Body Weight

Changes in body weight are presented in Tables 13 and 16. All the ewes lost some weight after treatment except the group that received 200 mg/kg. Nemafax in trial I which showed a slight gain in weight. The loses were, however, not significant.

Egg counts

All the ewes in trials I and II had high faecal egg counts before treatment. Two weeks after treatment, ewes in trial I that received Nemafax and Thiabendazole at 100 and 200 mg/kg. body weight passed out no nematode eggs. There was a decline in egg output of ewes that received Nemafax and Thiabendazole at 50 mg/kg body weight. The decrease was more pronounced in the group that received Thiabendazole (Table 14).

No nematode eggs were found in ewes in trial II that received Nemafax and Thiabendazole at 100 mg/kg body weight one week after treatment (Table 17). There were marked decreases in faecal egg output of all other ewes that received anthelmintics at various dosage levels one week after treatment (Table 17).

Worm Recovery

All the ewes in trial I which received Nemafax and Thiabendazole at 100 and 200 mg/kg body weight had all their helminths eliminated at end of 2 weeks post treatment. These included adult forms, developmental stages and inhibited larvae (Table 15). In ewes that received Nemafax at 50 mg/kg body weight, there was a significant reduction in the numbers of immature stages of Haemonchus spp. and complete elimination of adult forms of the same species. At this dosage level, all developmental forms and L_3 of Trichostrongylus spp. were eliminated and a sharp decrease in adult forms was recorded. For the ewes in this trial which received 50 mg/kg body weight of Thiabendazole, there was a significant reduction in adult, developmental and inhibited larval stages of Haemonchus spp. Like Nemafax, all L_3 and developmental stages of Trichostrongylus spp. were eliminated and a significant decrease in adult forms observed.

The ewes in trial II which received Nemafax and Thiabendazole at 100 mg/kg body weight had all the adult, developmental and inhibited larval forms of helminths eliminated (Table 18). A significant reduction in the 3 stages of development was observed in ewes that received Nemafax and Thiabendazole at 50 mg/kg body weight.

Loxon 2 at 25.5 mg/kg had no significant effect on inhibited larvae of Haemonchus spp. but made significant reduction of the adult and developmental stages of the same helminth. At same dosage, significant reduction of adult and immature stages of Trichostrongylus spp. was observed. At dosage level of 51 mg/kg, Loxon 2 reduced the numbers of Haemonchus spp. and Trichostrongylus spp. at all stages of development. Similar results were obtained from Ranide 7.58 mg/kg and 15.16 mg/kg.

Both Nemafax and Thiabendazole at 100 mg/kg were highly effective against inhibited larvae while Loxon 2 and Ranide at high dosages were only capable of reducing the number of inhibited larvae but not completely eliminating the infection.

Table 13

Mean and standard deviation of body weight per treatment group, before and after treatment of sheep used in trial I., April 1977.

Treatment group	Mean and standard deviation of weight before treatment (kg.)	Mean and standard deviation of weight 2 weeks after treatment (kg.)
Control	26.3 ± 4.6	23.2 ± 1.6
Nemafax 50 mg/kg	23.0 ± 1.4	22.7 ± 0.8
Thiabendazole 50 mg/kg.	22.2 ± 1.8	22.2 ± 1.7
Nemafax 100 mg/kg.	24,3 ± 1.2	23.0 ± 1.8
Thiabendazole 100 mg/kg	25.0 ± 0.9	24.3 ± 1.2
Nemafax 200 mg/kg	23.3 ± 1.9	24.8 ± 1.5
Thiabendazole 200 mg/kg.	24.2 ± 1.6	23.8 ± 2.0

Table 14

Mean and standard deviation of helminth eggs per gram of faeces per treatment group, before and after treatment of sheep used in trial I, April 1977.

Treatment group	Mean and standard deviation of Epg. before treatment	Mean and standard deviation of Epg 2 weeks after treatment
Control	2680 ± 1639	3,473 ± 2,045
Nemafax 50 mg/kg.	1630 ± 808	1,022 ± 1,969
Thiabendazole 50 mg/kg	2720 ± 2239	1,207 ± 1,594
Nemafax 100 mg/kg	4012 ± 1643	0
Thiabendazole 100 mg/kg.	3213 ± 659	0
Nemafax 200 mg/kg	3443 ± 2534	0
Thiabendazole 200 mg/kg.	3822 ± 2844	0

Table 15

Mean and standard deviation of worm counts per treatment group of the sheep used in trial 1, April 1977

Treatment group	*Haemonchus* spp.			*Trichostrongylus* spp.		
	Adult	Develop. stages	EL_4	Adult	Develop. stages	L_3
Control	375±379	616.7±564	683±571	7900±5391	291.7±398	75±117
Nemafax 50 mg/kg	0	450±432	41.7±80	195±400	0	0
Thiabendazole 50 mg/kg	283±343	508±631	83±160	266.7±653	0	0
Nemafax 100 mg/kg	0	0	0	0	0	0
Thiabendazole 100mg/kg	0	0	0	0	0	0
Nemafax 200 mg/kg	0	0	0	0	0	0
Thiabendazole 200mg/kg	0	0	0	0	0	0

Table 16

Mean and standard deviation of body weight per treatment group before and after treatment of sheep in trial 2, August 1977

Treatment group	Mean and standard deviation of weight before treatment	Mean and standard deviation of weight a week after treatment
Control	19.6 ± 3.0	18.5 ± 3.0
Nemafax 50 mg/kg	19.8 ± 1.3	19.6 ± 1.5
Thiabendazole 50 mg/kg	18.0 ± 2.6	17.3 ± 2.2
Loxon 2, 25.5 mg/kg	17.7 ± 2.3	17.0 ± 1.9
Ranide 7.58 mg/kg	16.8 ± 2.6	16.5 ± 2.5
Nemafax 100 mg/kg	22.3 ± 4.7	19.5 ± 1.3
Thiabendazole 100 mg/kg	18.0 ± 2.6	17.3 ± 2.2
Loxon 2, 51 mg/kg	20.2 ± 2.9	19.5 ± 2.7
Ranide 15.16 mg/kg	16.6 ± 3.4	16.2 ± 3.1

Table 17

Mean and standard deviation of helminth eggs per gram of faeces, per treatment group, before and after treatment of sheep in trial 2, August 1977.

Treatment group	Mean and standard deviation of Epg. before treatment.	Mean and standard deviation of Epg. a week after treatment
Control	21316.7 ± 46824	41306.7 ± 77981.4
Nemafax 50 mg/kg	7044.0 ± 5384.9	12 ± 26.8
Thiabendazole 50 mg/kg	1707.0 ± 536.9	205 ± 253.2
Loxon 2, 25.5 mg/kg	8236.7 ± 11723.3	3923 ± 3589.6
Ranide 7.58 mg/kg	24616.7 ± 43561.0	4046.7 ± 2528.0
Nemafax 100 mg/kg	6780.0 ± 3863.6	0
Thiabendazole 100 mg/kg	6985.0 ± 10163.0	0
Loxon 2, 51 mg/kg	3890.0 ± 1572.8	1966.7 ± 3070.0
Ranide 15.16 mg/kg	14144.0 ± 10582.8	1932 ± 1501.0

Table 18

Mean and standard deviation of worm counts, per treatment group of sheep in trial 2, August, 1977.

Treatment group	Haemonchus spp. Adult	Haemonchus spp. Dev. stages	Haemonchus spp. EL_4	Trichostrongylus spp. Adult	Trichostrongylus spp. Dev. stages	Trichostrongylus spp. L_3
Control	1516±863.0	733±355.9	4683±1802.0	10583 ±8073.0	400 ±236.0	566.7 ±301.0
Nemafax 50 mg/kg	20±44.7	280±249.0	1460±1434.6	40±89.4	320 ±228.0	80±130.4
Thiabendazole 50 mg/kg	100±141.0	117.5±102.7	2075±1445.0	87.5±118.0	0	100 ±141.0
Loxon 2, 25.5 mg/kg	433±294.0	233±242.0	4467±2049.0	350±207.0	450 ±288.0	133±175.0
Ranide 7.58 mg/kg	366.7±250.0	250±242.8	2933±2035.0	466.7 ±216.0	250 ±151.6	133±103.0
Nemafax 100 mg/kg	0	0	0	0	0	0
Thiabendazole 100mg/kg	0	0	0	0	0	0
Loxon 2, 51 mg/kg	266.7±265.8.0	133±136.6	3000±1516.6	266 ±250.0	166.7 ±81.6	233±250.0
Ranide 15.16 mg/kg	400±339.0	280±334.7	1740±1492.6	360 ±364.7	180 ±130.0	160±181.6

DISCUSSION

By the time the first part of this trial was carried out in April, pasture had been sterile for almost 4 months and as such, all that the experimental animals contained at the time of treatment were adult and inhibited larval stages of trichostrongyles. However, in the second part of the trial which was in August, animals contained adults, developmental stages and inhibited larvae because there was abundant moisture on pasture which favoured larval development.

Making a valid comparative percentage efficacy of the drugs used in both trials may not be worth while since animals were not infected experimentally with known amount of infective larvae but picked up their infection randomly on pasture. Hence the worm load varied with individual animal.

The period between treatment and slaughter was rather short. The changes in body weight during this period might not necessarily have been due to the drug treatment since this change was observed in the untreated controls too. Other factors like stress,isolation, special diet etc. could have produced temporary changes in weight. Weight loss observed immediately after treatment may also have been continuous effect of the damage done before the parasites were eliminated.

On the basis of comparative worm counts between treated and control lambs and pre-and post-treatment egg counts, Thiabendazole and Nemafax were

highly effective against all stages of development. Loxon 2 and Ranide were not very effective. The manufacturers of Loxon 2 (Cooper) have recommended that it should be used monthly throughout the wet season. Apparently, the efficacy of this drug is not to be based on a single application as in the case of this trial. The same recommendations have been made for Ranide by Merk, Sharp and Dohme and there is no existing record that relates the action of these two drugs against inhibited larvae.

Nemafax is a new drug on the Nigerian market and also its action against inhibited larvae of trichostrongyles has not been previously recorded.

The development of early fourth larval stage at which H. contortus gets inhibited and the larva three stage at which Trichostrongylus spp. gets inhibited takes 3 to 4 days after infection and sexual maturity is reached in about 2 weeks (Veglia, 1915). All animals after being treated were isolated under conditions that precluded reinfection for 2 weeks in the first trial and for 2 weeks before and one week after treatment in the second trial. It is evident then that all early larva 4 of Haemonchus spp or larva 3 of Trichostrongylus spp. found in the animals were inhibited larvae. Further evidence that these larvae were inhibited was provided by the presence within them of rod-like intestinal inclusions considered by Blitz and Gibbs (1971b) to be characteristic of inhibited forms.

The results of these trials partly confirmed previous studies that

Thiabendazole at 50 mg/kg (Gordon, 1964, Gibson, 1964) and at increased dosage level (Connan 1973; Mckenna, 1974a; Armour et al. 1975) is highly effective against adult and inhibited stages respectively of H. contortus. Colglazier et al. (1969, 1970) reported that Thiabendazole at 50 mg/kg was effective against inhibited larvae eliminating from 3% to 30% of infection. In contrast to the strain of H. contortus used in these trials, those used by the aforementioned authors showed some resistance to Thiabendazole at the adult stage. It is uncertain whether the low efficacy of this drug against inhibited larvae recorded by these authors were also reflections of this strain resistance or were more specifically due to the inhibited nature of the larvae.

The present results indicate that at 50 mg/kg Thiabendazole has only a relatively low efficacy against inhibited larvae.

The poor action of all known anthelmintics against inhibited larvae of Ostertagia ostertagi has been attributed to their physical inaccessibility deep within the abomasal mucosa, with the mucus cell hyperplasia present in such cases affording them added protection (Hotson, 1967), or to the fact that in the inhibited state the metabolic processes of such larvae are virtually suspended and thus do not absorb the anthelmintic administered (Armour, 1970). This latter view is supported by the findings of Raynaud (1968) who has shown that the anthelmintic sensitivity of early fourth stage

of O. ostertagi larvae in development is higher than that of inhibited larvae. While the metabolic activities of inhibited H. contortus larvae may be similarly suspended, such larvae are not associated with a histotropic phase (Blitz and Gibbs, 1971a), a fact which may partially explain their greater susceptibility to anthelmintic treatment. The high efficacy of Thiabendazole and Nemafax at increased dosage levels against inhibited trichostrongyle larvae suggests that these drugs may offer a feasible means of limiting trichostrongyle infection during the rainy season thereby preventing losses due to acute helminthiasis.

CHAPTER SIX

BLOOD PICTURE OF SHEEP IN ACUTE AND CHRONIC HELMINTHIASIS

INTRODUCTION

Various pathogens as well as changes in nutrition may alter the normal blood picture. Parasitism is one of the major causes of lowered blood values (Scalm, 1965) and, especially in small ruminants, helminthiasis is often incriminated as a major parasitic problem affecting the blood forming system. Some of the effects of helminths on the blood values are reviewed by Baker and Douglas (1966) and Symons (1969).

In an extensive work done in the Northern Guinea Savanna Zone of Nigeria, Kuil (1970) reported that in the Yankasa and Udah sheep, infestation with helminths was associated with decreased blood parameters especially PCV, Hb and serum proteins, the decrease being more pronounced in heavy infestations. Such helminths according to him are Haemonchus spp. Trichostrongylus spp., Strongyloides spp., Gaigeria spp, and Oesophagostomum spp. The purpose of this work was to investigate changes in haematological values in sheep suffering from acute and chronic helminthiasis under natural grazing conditions in the northern Guinea savanna of Nigeria.

MATERIALS and METHODS

The sheep used to evaluate the blood picture in acute and chronic helminthiasis were part of the animals used in the experiments described in chapters 3 and 4 which grazed contaminated pasture from June 1976 to June 1977. No animal on trial was treated with anthelmintics. Management of the sheep was as described in chapter 3.

Blood samples were taken weekly from the jugular vein and mixed with EDTA in tubes to prevent clotting. The values of red blood cells (RBC) and white blood cells (WBC) were determined using the coulter counter. The packed cell volume (PCV) was determined using the microhaematocrit centrifuge and haemoglobin concentration (Hb) determined spectrophotometrically using the cyanmethaemoglobin method. All sheep which died on pasture were necropsied. Those that died within 2 months of their stay on pasture with clinical signs of acute helminthiasis and which had no significant pathological findings were presumed to have died of acute helminthiasis. 23 sheep fell into this category. Sheep which were on pasture for 18 weeks and over before they died and which had signs of chronic helminthiasis with no significant pathological findings of other etiology apart from those associated with helminthiasis were presumed to

have died of chronic helminthiasis. 25 animals fell into this category. 20 out of the 23 sheep that died of acute helminthiasis were lambs which were coming to the pasture for the first time and as such had not built up any immunity.

RESULTS

Mean values of Epg, PCV, Hb and RBC of sheep which died on pasture with either acute or chronic helminthiasis are presented in Fig. 5 and Tables 19 - 23. Values from individual sheep are presented in appendix VI.

Sheep with acute helminthiasis had a rapid increase in egg output from week one to week seven. With the increase in helminth egg output, there occured rapid decline in the values of PCV, Hb and RBC. Initially there was an increase in WBC, followed by a decline by week 4 and a rise during week 7. There were wide fluctuations in WBC but no discernable pattern was observed. There was an initial increase in eosinophil numbers but these dropped towards the end of the seventh week. A progressive increase in the numbers of neutrophils and a fall in the numbers of lymphocytes were observed while monocyte numbers were unstable. In the group with chronic helminthiasis, helminth egg output was unsteady for a long time and was very low for the first seven weeks. There was a slow and steady fall in PCV, Hb

and RBC values. The values of WBC were quite unsteady with no apparent change except in weeks 8 and 9 of observation when a decline in values was recorded. The values of eosinophils also showed much fluctuation. There was an initial decline and a subsequent rise in the values of neutrophils and lymphocytes while the values of monocytes were unstable.

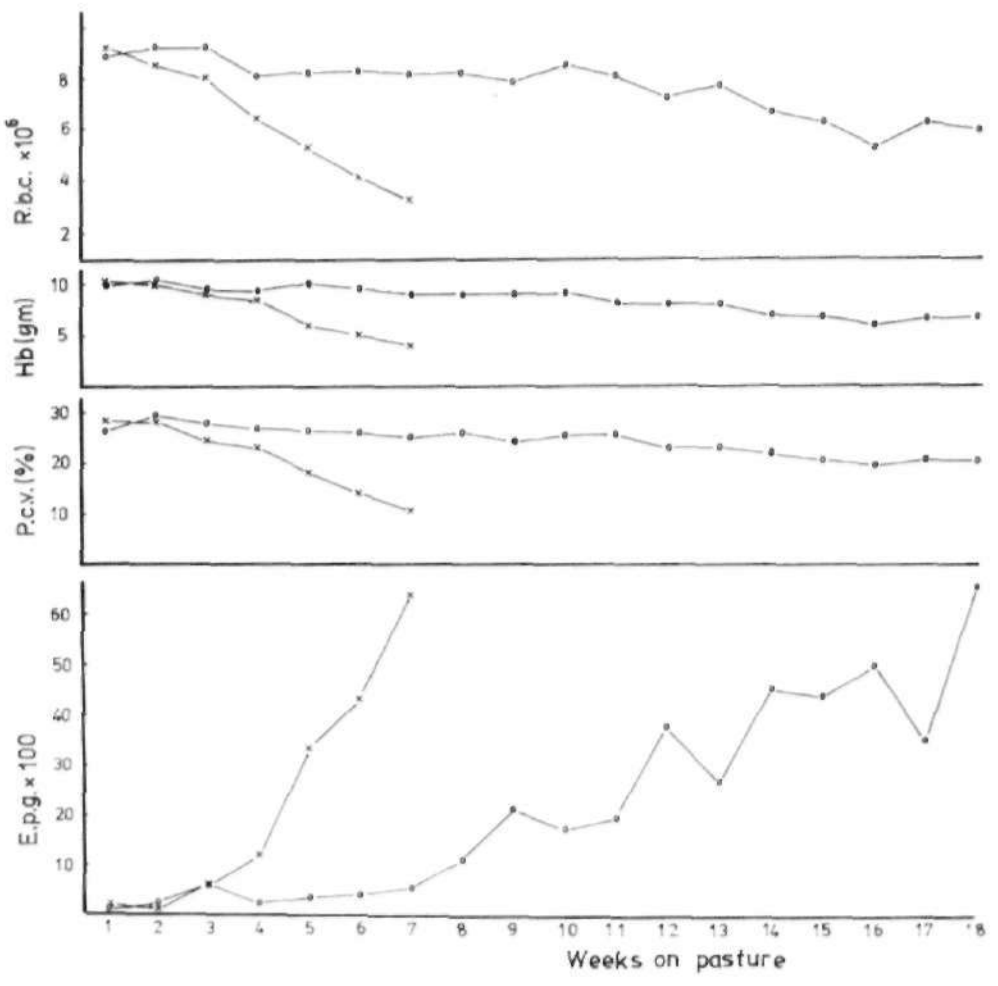

R.b.c. ×10⁶
8
6
4
2
Hb (gm)
10
5
P.c.v. (%)
30
20
10
E.p.g. × 100
60
50
40
30
20
10
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Weeks on pasture

Table 19

Mean and standard deviation of blood values of 23 sheep suffering from acute Helminthiasis

Week	EPG	PCV %	Hb (gm/dl.)	Total RBC ($X10^6$/cmm	Total WBC ($X10^3$/cmm)
1.	77.2 ± 37.12	27.9 ± 6.6	10.3 ± 2.6	9.2 ± 1.8	10.2 ± 3.8
2.	276.9 ± 1072.5	28.2 ± 7.0	10.2 ± 2.8	8.7 ± 1.8	11.3 ± 3.9
3.	639.6 ± 950.9	24.1 ± 6.2	8.7 ± 2.3	8.0 ± 1.8	10.0 ± 3.0
4.	1208.6 ± 292.3	23.2 ± 6.1	8.0 ± 2.0	6.4 ± 1.7	8.9 ± 2.4
5.	3395.9 ± 2203.6	18.4 ± 6.9	6.0 ± 1.4	5.2 ± 1.9	9.2 ± 3.3
6.	4345.8 ± 1793.1	14.2 ± 3.8	5.1 ± 1.2	4.0 ± 0.9	9.1 ± 2.8
7.	6410.6 ± 3670.6	10.8 ± 2.3	3.6 ± 0.8	3.3 ± 0.8	10.6 ± 2.9

Table 20

Mean and standard deviation of absolute differential leukocyte values of 23 sheep with acute helminthiasis

Week	Total WBC ($X10^3$/cmm)	Eosinophils	Neutrophils	Lymphocytes	Monocytes
1.	10.2 ± 3.8	118.7 ± 116.6	4624.0 ± 1356.5	5285.8 ± 1328.9	124.8±111.5
3.	10.0 ± 3.0	190.1 ± 162.2	4583.0 ± 1383.1	5025.8 ± 1335.3	134.3± 91.5
5.	9.2 ± 3.3	225.4 ± 243.8	4693.8 ± 1531.8	4414.6 ± 1480.3	81.9±100.3
7.	10.6 ± 2.9	131.7 ± 268.7	6395.4 ± 1287.1	4499.7 ± 1290.3	98.8±121.1

Table 21

Mean and standard deviation of blood values of 25 sheep suffering from chronic helminthiasis

Week	EPG	PCV %	Hb (gm/dl.)	Total RBC ($X10^6$/cmm)	Total WBC ($X10^3$/cmm)
1.	200 ± 500.8	27 ± 5.2	10.2 ± 1.8	9.0 ± 1.3	12.6 ± 3.7
2.	226.8 ± 335.2	29.1 ± 4.2	10.3 ± 1.7	9.3 ± 1.7	11.8 ± 3.1
3.	589.6 ± 902.6	27.8 ± 4.1	9.8 ± 1.7	9.2 ± 1.2	12.4 ± 3.4
4.	279.2 ± 315.6	27.3 ± 5.5	9.6 ± 2.2	8.0 ± 1.8	10.8 ± 3.4
5.	407.2 ± 423.5	26.6 ± 3.8	10.0 ± 1.4	8.2 ± 1.4	10.6 ± 2.6
6.	437.1 ± 750.1	26.3 ± 4.2	9.8 ± 1.5	8.3 ± 1.2	11.2 ± 2.6
7.	539.2 ± 462.1	24.7 ± 4.5	9.2 ± 1.9	8.1 ± 1.6	11.8 ± 2.7
8.	118 ± 801.2	25.6 ± 5.4	9.3 ± 1.5	8.3 ± 1.7	9.4 ± 2.7
9.	2591.2 ± 3375.3	24.4 ± 5.2	8.9 ± 2.4	7.8 ± 1.4	10.7 ± 3.0
10.	1793 ± 873.0	25.2 ± 4.7	8.9 ± 1.8	8.5 ± 2.0	12.1 ± 3.3
11.	2006.4 ± 1267.7	24.9 ± 5.3	7.7 ± 3.3	8.0 ± 2.0	11.7 ± 3.1
12.	3783.7 ± 3117.9	23.2 ± 5.1	8.1 ± 1.6	7.3 ± 1.4	11.8 ± 3.0
13.	2698.7 ± 2132.8	22.6 ± 4.1	8.0 ± 1.7	7.7 ± 1.6	13.9 ± 4.2
14.	4518.8 ± 3014.0	22.3 ± 4.3	7.1 ± 1.6	6.6 ± 1.3	12.4 ± 3.8
15.	4394.4 ± 3403.7	20.8 ± 4.1	6.8 ± 1.5	6.2 ± 0.5	11.4 ± 2.5
16.	5043.6 ± 4727.0	19.7 ± 5.1	5.6 ± 1.5	5.3 ± 1.6	11.4 ± 3.8
17.	3511.5 ± 3620.7	20.6 ± 4.3	6.5 ± 1.5	6.2 ± 1.5	12.5 ± 3.0
18.	6549.5 ± 8518.0	20.3 ± 4.2	6.5 ± 1.6	5.9 ± 1.5	12.5 ± 3.3

Table 22

Mean and standard deviation of absolute differential leukocyte values of 25 sheep with chronic helminthiasis

Week	Total WBC ($X10^3$/cmm)	Eosinophils	Neutrophils	Lymphocytes	Monocytes
1.	12.6 ± 3.7	718.2 ± 594.7	5045.0 ± 1654.4	6615 ± 1541.0	221.8 ± 178.9
3.	12.4 ± 3.4	560.7 ± 426.1	4695.5 ± 1782.1	6446.7 ± 1950.1	126.0 ± 134.6
5.	10.6 ± 2.6	517.1 ± 320.3	4607.1 ± 1000.2	5511.5 ± 1108.7	110.7 ± 119.2
7.	11.8 ± 2.7	737.4 ± 395.1	5115.6 ± 898.5	5742.4 ± 972.6	168.2 ± 185.8
9.	10.7 ± 3.0	653.9 ± 331.3	4379.1 ± 757.9	5551.9 ± 746.1	166.2 ± 125.4
11.	11.7 ± 3.1	487.6 ± 300.0	4876.6 ± 1446.3	6478.8 ± 1434.5	89.1 ± 111.3
13.	13.9 ± 4.2	749.4 ± 532.1	6191.9 ± 1472.4	6855 ± 1355.4	217.3 ± 163.0
15.	11.4 ± 2.5	467.9 ± 378.7	5133.1 ± 966.7	5631.9 ± 1029.6	239.1 ± 241.4
17.	12.5 ± 3.0	452.3 ± 392.2	6212.4 ± 1784.3	5406.7 ± 1259.3	174.2 ± 266.9

Table 23

Means and standard deviation of worms recovered from two groups of sheep with acute and chronic helminthiasis

Group	*Haemonchus* spp.		*Trichostrongylus* spp.		*Strongyloides* spp.	Others*
	Adult	Immature	Adult	Immature		
Acute	1945 ± 905	1630 ± 1849	4137 ± 3657	941 ± 1126	880 ± 790	122 ± 157
Chronic	213 ± 231	8040 ± 4811	12904±4480	624 ± 1373	196 ± 534	44 ± 104

* Comprises of *Oesophagostomum* spp., *Cooperia* spp., and *Impalaia nudicollis*

Weekly comparison of the two groups:

Week 1

Both groups had similar blood values except that the values of eosinophils and monocytes were higher in the group with chronic helminthiasis (tables 20 and 22).

Week 2

There were no significant differences in the values of the blood parameters between the two groups except for higher RBC and WBC values in the group with chronic helminthiasis.

Week 3

Significant decreases were observed in PCV and Hb of sheep with acute helminthiasis while no significant changes in these parameters were observed in the group with chronic helminthiasis.

Although total WBC of acute group did not change significantly in week 3, a slight increase in eosinophil counts was recorded over the previous week. No significant haematologic changes were observed in the

group with chronic helminthiasis during week 3. It should be noted that the changes in blood values in the acute group were accompanied by progressive increase in total egg output.

Week 4

There was continued decrease in PCV, Hb and RBC values of sheep with acute helminthiasis. A leukopenia was also observed. By the end of week 4, PCV, Hb and RBC values had decreased by about 20% from start of experiment. The decline in these parameters in sheep with chronic helminthiasis continued to be more gradual.

Week 5

Helminth egg output in the group with acute disease had risen to about 8 fold of the chronic group.

PCV, Hb., and RBC had dropped significantly to about 60% of the original values in the group with acute infection while in the group with chronic helminthiasis, no significant changes occured in these parameters.

The values of lymphocytes and monocytes had dropped significantly in both groups. Eosinopils had made significant increase in the acute

group but a significant decrease in the chronic group.

Week 6

Helminth egg output was low in the group with chronic helminthiasis while this was significantly higher ($P<.05$) in the group with acute helminthiasis. PCV, Hb and RBC values had dropped to about 50% of original values in the group with acute helminthiasis while there were no significant changes in these values in the chronic group. In both groups, no remarkable changes occured in WBC values.

Week 7

In the group with acute infection, egg output exceeded 6000 per gram of animal faeces while this was still around 500 per gram in the group with chronic helminthiasis. Similarly in the group with acute infection, values of PCV, Hb and RBC had dropped very low with no significant changes in the WBC value, and there had been significant increase in the value of neutrophils. At the 7th week of the chronic infection, there was no significant drop ($P>0.05$) in the values of PCV, Hb and RBC. WBC values were still near initial value. There were slight increases in the eosinophil, neutrophil, lymphocyte and monocyte values

over the previous week. As can be seen (tables 21 and 22), the decline in blood parameters of sheep with chronic helminthiasis was much more gradual. The blood values declined as the egg output increased. By week 18, the helminth egg output was more than 30 fold the initial values of week 1 while the PCV had dropped by 26% of original values. Hb values fell by 36% while RBC values dropped by 34%. No significant changes in total leukocytes were observed in the course of the study. Haemonchus spp. and Trichostrongylus spp. were the principal worms recovered from dead sheep. It is evident from table 23 that sheep which died of acute helminthiasis had large numbers of Haemonchus spp. and Trichostrongylus spp. both adults and immature. They also contained strongyloides spp. in high numbers. Those that died of chronic helminthiasis had fewer Haemonchus adults but large numbers of adult Trichostrongylus spp. and inhibited larvae of Haemonchus spp.

DISCUSSION

At the beginning of the study, the ewes had very low egg counts while the lambs were free of worms. With the arrival of the rains, favourable conditions for egg and larval development existed on the pasture. There occured a build up of infective larvae and within a short period, all the sheep on this contaminated pasture got infected

with helminths.

Since uniform husbandry practices were maintained on the pasture during the experimental period, the haematological changes observed are credited to the effects of the helminth burden on the host. Most of the sheep which developed acute helminthiasis were worm-free at the time they were introduced on the pasture. These animals rapidly developed anaemia which was related to the degree of helminth egg output. Similar observations were made by Allonby (1973) in East Africa. He classified acute haemonchosis as lasting from 1 to 6 weeks with anaemia and faecal egg output of up to 100,000 epg.

In this study, animals classified as manifesting chronic helminthiasis were on pasture for up to 18 weeks before they died. The disease was characterized by a gradual but progressive decrease in Hb and PCV in association with increased numbers of faecal egg output. Allonby and Urquihart (1975) made similar findings in Merino sheep suffering from chronic helminthiasis in East Africa. They found that in chronic infection lasting several months, mean PCV and Hb values dropped progressively from 33% to 25% and 11 gm/dl. to 7 gm/dl. respectively.

A large number of adult Haemonchus spp was recovered from the animals that suffered the acute infection. Clark et al (1962) estimated that each adult Haemonchus spp. draws about 0.049 ml. of blood per day

from the host. Given the degree of infection, it can be concluded that the anaemia which developed in the sheep during this time was due to blood loss from the sucking activities of these worms. Dargie and Allonby (1975) described 3 stages in the development of anaemia in sheep suffering from haemonchosis. Stage 1 is said to occur in the first 3 weeks with progressive fall in PCV, low egg count and normal serum iron level caused by blood sucking developing stages and a latency in the response of host erythropoietic system. Stage 2 is accompanied by continuous abomasal haemorrhage and mass stimulation of erythropoiesis while stage 3 is characterized by dramatic reduction in PCV and serum iron concentration showing exhaustion of the host's synthetic machinery due to deficiencies of iron and possibly available protein. Most of the sheep in the acute group were coming to pasture for the first time in their life because they were born during the previous dry season when no grass was available for pasturing. They had not been exposed to helminth infection and as such had not built up any immune response. The ewes which had had experience with helminth infection were able to mount some resistance and they developed a chronic infection. Similar findings were made by Anosa (1977) who observed that lambs 4 to 6½ months old showed signs of severe parasitism and anaemia while ewes were only

mildly parasitized with low faecal egg counts and a mild depression of red cell indices. The presence of immune antibodies in sheep enables the sheep to throw off their own worm burden and to further prevent infection by immobilizing the larvae in the gastric and intestinal mucosa (Hawkins and Cole, 1945).

The sheep which died of chronic helminthiasis contained a large number of Trichostrongylus spp and a fewer number of adult Haemonchus spp. Trichostrongylus spp. are not renowned blood suckers like Haemonchus spp. The pathogenesis of the anaemia in the chronic group may therefore be explained by the facts that the few adult Haemonchus burden could still suck a reasonable amount of blood from the hosts although not to the extent we found in the acute group. According to Baker and Douglas (1966), the anaemia associated with heavy Trichostrongylus spp. infection is due to shortening of the life of erythrocytes, impared erythropoiesis and reduction of the amino acid pool. In their own finding, Horak et al (1968) indicated that anaemia in Trichostrongylus colubriformis infection is caused by a toxin excreted by the helminth which may depress erythropoiesis and Baker (1973) associated the anaemia in Trichostrongylus spp. infection with inhibition of iron intake, its reduced storage and transport, resulting from changes in intestinal epithelial cells or loss of plasma transferrin to the gut. These reasons could as well explain the cause of

the anaemia found in the group with chronic helminthiasis in this study since a very large number of adult Trichostrongylus spp. was involved.

In both acute and chronic cases, no significant changes in total leukocyte counts were noted, the values fluctuating within normal limits for sheep in this area. Fluctuations were noted in the values of eosinophils, neutrophils and lymphocytes in both groups of sheep. Todd and Wyant (1951) found in sheep infected with Ostertagia spp. that some showed leukopaenia on initial infection. This decrease was arrested and restored near the time of sexual maturity of the parasites but was later resumed. Following a second exposure of the animals to the parasites, the total leukocytes and absolute lymphocytic and neutrophilic counts made moderate progressive increases.

In the present study, the initial eosinophilia observed in both acute and chronic cases was probably due to the migrating activities of immature forms in the animals' tissues.

CHAPTER SEVEN

GENERAL DISCUSSION AND CONCLUSIONS

In most parts of the world, under natural conditions, free-living stages of helminths show seasonal fluctuations induced by several environmental factors of which the most important are temperature and humidity. A moderate temperature with a high humidity is quite favourable for egg and larval development. Humidity of the micro-climate does not only depend on rainfall but on factors influencing the amount of moisture which remains in the soil, for example, soil structure, shade, drainage and vegetation type. Rainfall is necessary for the dissemination of larval stages on pasture while herbage length can affect the availability of these larvae. Most larvae are concentrated in the lower quarter and hence, the short, overgrazed herbage will increase their availability but this will also increase their exposure to adverse weather factors especially desiccation.

In this study, under the conditions that exist in the northern Guinea Savanna, the 6-month long dry season ended in April. The rains started in May and by the first half of June, pasture turned green and became infective with the availability of suitable conditions for larval

development. The rains stopped by October and from November, pasture infectivity started to decline until in January when the presence of helminth larvae was nil on pasture due to very low humidity conditioned by prolonged lack of rainfall. All grasses and shrubs on the unimproved pasture had dried up. The alternation of the dry atmosphere with the cold hamattan made it impossible for larvae to survive on an almost grassless pasture.

Based on the results of investigations reported here, it is postulated that the phenomenon of larval inhibition makes a significant contribution to contamination of pasture at the beginning of the rains. Larvae ingested during the dry season when conditions are unsuitable for the free-living stages, inhibit their development and on becoming adults contaminate the pasture.

Factors which have been incriminated as contributing to inhibition include host immunity, (Blitz & Gibbs, 1971a), environmental stimuli (Connan, 1975), and presence in the host of high number of adult worm population (Dunsmore, 1963; Michel, 1971). Under the conditions of our studies, host immunity did not appear to be a major cause since the pattern of inhibition in unimmuned helminth-free lambs did not differ significantly from that in the ewes which had been exposed to natural

infection. The level of infestation of sheep with adult helminths did not appear to be a very significant factor in the initiation of the inhibition phenomenon since sheep used in this study had low numbers of adult Haemonchus spp. during the months of the dry season and still larval inhibition did occur. Another suggestion, that larval inhibition is brought about primarily by environmental stimuli acting on the preparasitic stages, may have been the major cause of the phenomenon under the conditions of this study especially as there is seasonal involvement but the fact that cultured larvae which had not been exposed to field conditions also underwent inhibited development weakens this assumption. It had been postulated that inhibited larvae are triggered into normal development by receipt of signals (Blitz and Gibbs, 1971a; Connan, 1975), and the suggestions advanced include a hypothalamic-hypophysal stimulus and an environmental stimulus. The nature of the signals could not be elucidated in this study, but the fact that inhibited larvae come out of inhibition in April just before the rains start, implicates an environmental stimulus.

The phenomenon of larval inhibition in both Haemonchus spp. and Trichostrongylus spp. is responsible for recontamination of pastures at the beginning of the rainy season due to their resumed development. Clinical helminthiasis is most common at this time of the year in untreated

flocks. In the present study, from June to December, 67 out of the 168 sheep that were put on pasture died mostly from helminthiasis and combination of helminthiasis with coccidiosis. This mortality rate of almost 40% is very high especially when very large herds are involved. Young lambs were particularly susceptible and most of this group that died suffered from acute infection. The ewes were initially able to put up some resistance to infection but in several of them, the resistance soon broke down either due to weak immunity or breaking down of the immune resistance as a result of large number of helminth being acquired. This aspect therefore demands the establishment of satisfactory husbandry method and a regime of helminth control by routine antheimintic drenching in order to minimize casualties due to helminthiasis.

It follows that if inhibited larvae could be destroyed in the host by antheimintic treatment, the possibility of adult sheep carrying inhibited larvae contaminating the pasture after the dry season would be eliminated.

The low metabolic rate of inhibited larvae and the fact that they are not free-living in the host but embedded in the abomasal mucosa make them inaccessible to routine antheimintics. Results of these antheimintic trials show that routine antheimintic treatment of adult sheep early in

the rainy season only destroys adult helminths and perhaps a few developmental stages but not inhibited forms. However, Thiabendazole and Nemafax were found to be effective against inhibited larvae at high dosage levels.

It is thus evident that given a closed herd and fenced pasture, sheep grazing in such a pasture could be treated with either Thiabendazole or Nemafax at the end of the dry season at double the recommended dose and would be free of inhibited larvae and consequently could not contaminate the pasture again in the following rainy season. It must be emphasized that this recommendation is of practical application only in closed herds. In non-closed herds, it is economically wasteful and may even lead to drug resistance, particularly if imidazole derivatives are used.

Loxon 2 and Ranide are not quite effective against inhibited larvae even at 51 mg/kg and 15.16 mg/kg respectively.

Both acute and chronic helminthiasis occur in Nigerian sheep. The tissue most adversely affected is the blood.

Under the conditions of our experiments, acute helminthiasis occured early in the rainy season in lambs and lasted from 6 to 8 weeks. It was associated with high faecal egg counts, large numbers of adult helminth and anaemia. H. contortus was the predominant helminth in the acute cases of helminthiasis.

Chronic helminthiasis occured mostly in adult sheep and lasted up to four months and longer. It was associated with decreased or fluctuating faecal egg counts, anaemia and diarrhoea. Most of the helminths recovered were Trichostrongylus spp. and inhibited Haemonchus spp.

The onset of anaemia in lambs with acute helminthiasis was rapid as evidenced by rapid decline in circulating haemoglobin, erythrocytes and haematocrit. It has been shown that the anaemia of acute helminthiasis arises from rapid blood loss brought about by the blood sucking activities of adult Haemonchus spp. as well as the stage 5 larvae (Clark et al., 1962).

The development of anaemia in sheep with chronic helminthiasis was gradual in nature. The mechanism of anaemia of chronic helminthiasis in this study could not be related to blood loss since the principal helminths involved (Trichostrongylus spp.) are not known to be blood suckers. It has been suggested that such anaemia arises from impared erythropoiesis and a decrease in the amino acid pool (Baker and Douglas, 1966; Horak et al., 1968).

These differences in pathogenesis of anaemia in helminthiasis need to be taken into account in the clinical Management of these dissimilar conditions.

The results of these studies highlight the need to investigate

further the phenomenon of larval inhibition as seen in the Northern Guinea Savanna Zone. It is also apparent that with improved husbandary and management practices, it should be possible to control and even eliminate helminthiasis as a serious disease of small ruminants by judicious use of efficable drugs. More research is needed into drugs effective against inhibited larval forms of helminths.

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APPENDIX I

Weather records for the University Farm from June 1976 to June 1977 compiled from the Meteorological section of the Institute for Agricultural Research, Samaru, Zaria.

Table 24

Weather records for JUNE 1976

Days of the month	Rain-fall (mm)	Max. Temp. (°C)	Min. Temp. (°C)	Rel. Hum. 10 a.m. (%)	Rel. Hum. 4 p.m. (%)	Soil temperature °C at 2"	1ft.	4ft
1	-	29	21	77	61	28	27.2	27.8
2	3.7	32	21	64	49	29	27.4	27.7
3.	-	31	20	62	58	27	27.1	27.7
4	-	31	22	76	53	27	27.4	27.7
5	12.9	30	23	65	61	30	27.3	27.7
6	-	30	18	69	61	27	26.1	27.7
7	-	31	19	63	56	26	26.4	27.6
8	34.0	31	18	58	70	28	26.8	27.5
9	-	30	17	85	58	23	26.9	27.4
10	31.5	26	20	81	88	26	26.1	27.5
11	1.9	26	18	87	85	25	25.0	27.4
12	-	29	19	85	64	25	24.6	27.4
13	-	31	21	75	58	28	25.5	27.0
14	-	32	21	80	56	28	26.6	27.0
15	24.9	32	20	69	65	28	27.1	27.0
16	-	29	18	79	58	25	26.7	27.0
17	9.4	30	19	83	81	26	26.1	27.0
18	2.6	26	19	76	62	26	26.0	27.0
19	-	28	19	72	68	30	25.5	27.0
20	16.9	29	20	78	60	26	25.9	27.0
21	-	28	18	77	63	24	25.5	26.9
22	0.2	30	20	78	56	28	25.7	26.9
23	14.5	31	20	73	56	27	26.3	26.9
24	-	28	17	74	63	25	26.2	26.9
25	-	29	20	76	60	25	26.0	26.9
26	5.8	30	21	79	62	27	26.2	26.9
27	3.0	30	20	79	60	28	26.4	26.7
28	-	29	19	75	56	26	26.6	26.9
29	45.6	29	20	84	62	25	26.5	26.8
30	-	29	18	80	70	24	26.0	27.0

Table 25

Weather records for JULY 1976

Days of the month	Rain-fall (mm)	Max. Temp. (°C)	Min. Temp. (°C)	Rel. Hum. 10 a.m. (%)	Rel. Hum 4 p.m. (%)	Soil temperature °C at 2"	1ft	4ft
1	26.6	29	21	71	67	26	26.1	27.0
2	-	29	19	73	65	26	26.0	26.8
3	29.9	30	21	79	63	27	26.6	26.8
4	17.5	26	17	83	83	27	26.4	26.9
5	Trace	27	19	79	69	25	25.1	26.9
6	-	26	18	88	71	24	25.9	26.9
7	-	28	19	77	61	27	25.7	26.7
8	17.1	28	19	79	64	26	25.8	26.6
9	-	25	20	92	66	24	25.7	26.7
10	-	26	20	89	74	24	25.3	26.7
11	-	28	20	78	66	26	25.3	26.6
12	9.3	27	20	89	58	25	25.5	26.5
13	15.8	29	19	77	61	27	25.5	26.5
14	16.0	28	20	88	91	26	25.9	26.5
15	-	28	20	86	66	25	25.6	26.4
16	22.6	28	20	91	72	24	25.9	26.4
17	-	27	17	77	68	25	25.7	26.5
18	22.4	28	20	77	65	25	25.6	26.5
19	-	26	18	83	77	24	25.5	26.4
20	-	28	20	84	63	25	25.0	26.4
21	2.6	26	20	88	81	24	25.4	26.3
22	3.5	28	20	84	62	25	25.0	26.4
23	20.0	29	20	79	69	26	25.4	26.3
24	9.0	29	19	72	63	28	25.5	26.3
25	7.3	29	18	77	64	27	26.0	26.2
26	-	28	19	83	64	26	26.0	26.3
27	-	30	18	76	59	25	25.9	26.3
28	-	29	20	76	62	27	26.3	26.3
29	0.8	24	21	77	91	25	23.3	26.4
30	-	27	20	82	72	24	25.4	26.4
31	6.0	29	19	80	60	25	25.0	26.4

Table 26

Weather records for AUGUST 1976

Days of the month	Rain-fall (mm)	Max. Temp. (°C)	Min. Temp. (°C)	Rel. Hum. 10 a.m. (%)	Rel. Hum. 4 p.m. (%)	Soil temperature °C at 2"	1ft	4ft.
1	27.5	27	18	85	66	24	25.3	26.4
2	-	27	19	87	72	25	25.3	26.3
3	1.5	27	20	85	73	26	25.5	26.3
4	22.8	28	20	80	66	25	25.7	26.1
5	Trace	25	19	90	77	24	25.4	26.1
6	-	26	20	88	71	24	24.9	26.1
7	41.5	29	19	76	64	25	24.9	26.1
8	-	26	17	100	74	21	24.0	26.0
9	18.2	26	18	80	80	24	24.7	26.0
10	Trace	26	18	73	79	25	24.3	26.0
11	-	27	20	87	74	24	24.8	25.9
12	-	25	19	89	74	23	24.9	25.8
13	-	29	20	76	57	25	24.5	25.8
14	23.9	30	20	87	61	26	25.4	25.8
15	3.5	27	18	96	69	23	25.3	25.8
16	18.2	27	19	87	72	24	25.0	25.8
17	7.7	29	18	26	69	25	25.1	25.9
18	-	30	18	62	53	25	25.2	25.8
19	4.4	26	20	77	71	27	25.9	25.9
20	2.3	28	20	77	67	26	25.4	25.9
21	Trace	29	20	78	67	26	25.6	25.9
22	-	31	20	75	52	27	25.8	25.8
23	-	28	20	77	68	26	26.1	26.0
24	-	28	20	79	66	25	26.0	26.0
25	-	28	20	84	66	25	26.0	26.1
26	Trace	31	20	88	55	26	25.6	26.0
27	14.5	26	18	76	76	26	25.8	26.0
28	22.1	29	17	74	60	25	24.9	26.0
29	Trace	27	18	82	67	24	25.0	26.0
30	-	28	20	76	67	25	25.3	26.0
31	-	28	19	76	66	26	25.5	26.0

Table 27

Weather records for SEPTEMBER 1976

Days of the month	Rain-fall (mm)	Max. Temp. (°C)	Min. Temp. (°C)	Rel. Hum. 10 a.m. (%)	Rel. Hum. 4 p.m. (%)	Soil temperature °C at 2"	1ft	4ft.
1	26.2	28	18	79	64	25	25.5	26.0
2	-	29	18	68	62	26	25.0	26.0
3	14.3	30	18	71	62	27	25.7	25.9
4	9.1	29	20	77	63	26	25.9	26.0
5	-	28	19	79	66	26	25.7	26.0
6	18.6	27	20	79	76	25	25.9	26.0
7	Trace	26	18	78	73	25	25.3	26.0
8	0.8	29	20	75	60	26	25.3	26.1
9	-	28	21	82	69	26	25.9	26.0
10	25.0	30	20	81	59	26	26.0	26.0
11	-	29	19	79	66	24	25.9	26.0
12	-	31	18	59	45	27	25.8	26.2
13	4.3	30	19	72	48	28	26.3	26.2
14	3.4	30	20	77	59	26	26.3	26.3
15	-	30	19	64	55	27	26.4	26.3
16	-	32	21	73	53	28	26.7	26.3
17	-	30	20	70	61	27	27.0	26.4
18	11.6	31	19	73	51	27	26.8	26.4
19	-	29	18	78	64	26	26.6	26.5
20	16.2	29	20	79	60	27	26.5	26.5
21	3.2	28	19	76	61	26	26.5	26.5
22	42.5	30	19	74	56	27	26.4	26.5
23	4.7	29	18	80	56	25	26.0	26.5
24	1.2	28	19	87	55	25	26.3	26.5
25	-	29	19	70	62	28	26.0	26.5
26	-	30	20	74	56	27	26.3	26.4
27	-	27	20	82	71	25	26.6	26.4
28	9.9	29	20	79	61	26	26.3	26.5
29	-	30	19	71	46	26	26.4	26.4
30	-	30	18	65	57	27	26.2	26.5

Table 28

Weather records for OCTOBER 1976

Days of the month	Rain-fall (mm)	Max. Temp. (°C)	Min. Temp. (°C)	Rel. Hum. 10 a.m. (%)	Rel. Hum. 4 p.m. (%)	Soil temperature °C at 2"	1ft	4ft.
1	1.9	31	20	73	95	29	26.8	26.4
2	-	27	19	82	54	30	26.7	26.5
3	2.3	29	20	79	65	30	26.4	26.5
4	-	30	18	66	59	31	26.5	26.5
5	2.8	30	19	69	58	31	21.8	26.5
6	Trace	31	19	71	57	32	26.9	26.5
7	5.5	31	20	75	81	31	27.0	26.5
8	-	30	18	72	64	30	26.5	26.5
9	0.9	31	19	60	56	30	26.5	26.5
10	Trace	30	20	57	79	30	26.8	26.5
11	-	27	19	83	68	27	26.4	26.5
12	1.8	30	20	66	56	30	26.5	26.4
13	24.6	31	20	67	63	31	26.9	26.5
14	-	30	19	67	55	30	26.5	26.4
15	11.7	30	21	76	58	30	26.5	26.5
16	46.8	28	18	76	95	23	25.8	26.4
17	Trace	26	18	88	67	26	25.5	26.5
18	-	29	19	70	68	29	25.4	26.5
19	10.5	30	19	73	99	27	25.7	26.5
20	31.4	29	20	75	60	30	25.7	26.4
21	1.5	25	19	100	79	26	25.0	26.3
22	-	30	19	72	61	30	25.4	26.2
23	7.0	30	20	75	65	30	25.9	26.1
24	Trace	28	19	94	66	29	25.7	26.0
25	2.6	30	21	87	98	26	26.0	26.0
26	-	30	19	68	47	30	26.0	26.0
27	-	30	20	73	60	30	26.4	26.1
28	10.9	30	21	91	98	27	26.6	26.0
29	-	30	18	60	64	29	26.2	26.2
30	-	30	18	81	45	30	26.2	26.2
31	-	30	19	76	47	29	26.2	26.3

Table 29

Weather records for NOVEMBER 1976

Days of the month	Rain-fall (mm)	Max. Temp. (°C)	Min. Temp. (°C)	Rel. Hum. 10 a.m. (%)	Rel. Hum. 4 p.m. (%)	Soil temperature °C at 2"	1ft.	4ft.
1	-	30	18	60	47	26	25.9	26.3
2	-	31	17	81	39	26	25.4	26.2
3	-	31	16	73	36	26	25.4	26.1
4	-	31	16	61	48	27	25.4	26.2
5	-	30	18	67	53	26	25.4	26.2
6	-	28	18	75	61	26	25.5	26.1
7	-	32	16	54	36	27	25.0	26.4
8	-	31	18	71	34	27	25.2	26.3
9	-	30	14	82	29	26	25.0	26.0
10	-	30	13	50	26	25	24.4	26.0
11	-	30	11	29	21	24	23.9	25.9
12	-	30	11	36	23	23	23.4	25.7
13	-	30	11	31	25	23	23.0	25.7
14	-	30	11	27	22	23	23.0	25.6
15	-	30	12	23	26	24	23.0	25.5
16	-	30	11	20	23	23	22.8	25.4
17	-	30	10	26	30	24	22.6	25.3
18	-	31	12	32	26	24	22.8	25.2
19	-	32	13	37	22	24	23.2	25.0
20	-	32	14	43	35	25	23.2	24.9
21	-	32	10	42	19	23	23.0	24.9
22	-	31	10	28	22	25	22.9	24.9
23	-	31	9	17	12	24	22.8	24.9
24	-	32	9	24	13	24	22.5	24.8
25	-	31	10	21	20	23	22.5	24.7
26	-	29	12	23	18	22	22.4	24.3
27	-	26	17	11	17	21	22.0	20.4
28	-	25	10	25	8	20	21.6	24.5
29	-	25	11	32	19	20	22.4	24.4
30	-	26	9	23	25	20	21.4	24.3

Table 30

Weather records for DECEMBER 1976

Days of the month	Rain-fall (mm)	Max. Temp. (°C)	Min. Temp. (°C)	Rel. Hum. 10 a.m. (%)	Rel. Hum. 4 p.m. (%)	Soil temperature °C at 2"	1ft.	4ft.
1	-	25	9	24	26	20	20.9	24.3
2	-	26	10	15	24	20	20.8	24.1
3	-	29	10	22	10	21	20.9	24.0
4	-	30	10	23	22	22	21.2	23.9
5	-	31	11	26	18	22	21.6	23.8
6	-	31	9	16	15	22	21.7	23.8
7	-	30	15	22	18	22	21.8	23.9
8	-	28	11	8	10	21	21.6	23.8
9	-	27	12	12	15	21	21.4	23.9
10	-	25	8	22	5	20	21.2	23.8
11	-	27	11	25	4	20	20.9	23.8
12	-	28	10	18	4	22	21.0	24.6
13	-	29	10	19	3	20	21.0	23.6
14	-	29	11	13	18	21	21.3	23.5
15	-	30	14	16	16	21	21.5	23.5
16	-	30	12	20	16	21	21.5	23.5
17	-	30	15	23	21	21	21.7	23.5
18	-	29	15	22	16	21	21.8	23.5
19	-	30	11	18	11	21	21.5	23.5
20	-	30	9	17	16	21	21.4	23.5
21	-	31	9	21	17	21	21.4	23.5
22	-	32	10	25	23	22	21.7	28.5
23	-	31	12	31	10	22	21.8	23.5
24	-	32	12	23	19	23	21.7	23.5
25	-	33	11	20	22	22	21.8	23.5
26	-	32	11	27	23	23	22.2	23.5
27	-	34	13	36	19	24	22.4	23.5
28	-	32	13	21	18	23	22.5	23.5
29	-	32	13	41	20	24	22.4	23.5
30	-	31	14	19	18	23	22.5	23.6
31	-	31	12	8	22	21	22.6	23.7

Table 31

Weather records for JANUARY 1977

Days of the month	Rain-fall (mm)	Max. Temp. (°C)	Min. Temp. (°C)	Rel. Hum. 10 a.m. (%)	Rel. Hum. 4 p.m. (%)	Soil temperature °C at 2"	1ft	4ft.
1	-	30	11	49	34	22	22.3	23.7
2	-	31	9	12	34	21	22.0	23.7
3	-	30	11	16	35	22	22.8	23.2
4	-	29	13	17	37	22	21.9	23.7
5	-	28	14	21	9	22	21.8	23.6
6	-	27	11	25	34	21	21.8	23.6
7	-	28	12	24	26	21	21.3	23.6
8	-	27	14	23	24	21	21.3	23.5
9	-	30	11	17	14	23	21.2	23.5
10	-	31	12	22	26	23	21.7	23.5
11	-	31	11	17	17	21	21.8	23.5
12	-	30	12	14	12	22	21.8	23.5
13	-	31	11	8	11	22	21.8	23.5
14	-	31	15	13	10	24	22.2	23.5
15	-	30	14	16	15	21	22.4	23.5
16	-	28	15	20	19	22	22.4	23.6
17	-	28	11	19	17	22	22.1	23.5
18	-	29	12	14	13	23	22.0	23.5
19	-	30	10	16	13	21	21.7	23.5
20	-	30	11	11	17	22	21.8	23.5
21	-	29	13	20	15	21	22.0	23.5
22	-	30	16	33	16	22	22.2	23.5
23	-	31	14	19	19	24	22.2	23.5
24	-	33	14	18	24	24	22.6	23.5
25	-	33	15	19	33	24	23.0	23.5
26	-	30	15	17	7	23	23.0	23.5
27	-	25	14	35	20	23	23.0	23.5
28	-	25	12	25	21	21	22.4	23.6
29	-	26	14	22	17	21	21.9	23.6
30	-	29	14	23	23	22	22.2	23.6
31	-	30	14	18	15	23	22.4	23.5

Table 32

Weather records for FEBRUARY 1977

Days of the month	Rain-fall (mm)	Max. Temp. (°C)	Min. Temp. (°C)	Rel. Hum. 10 a.m. (%)	Rel. Hum. 4 p.m. (%)	Soil temperature °C at 2"	1ft.	4ft.
1	-	32	11	14	20	22	22.3	23.5
2	-	34	13	15	15	23	22.6	23.5
3	-	32	14	11	9	23	23.0	23.4
4	-	27	13	21	16	22	23.2	23.6
5	-	26	12	24	14	21	22.7	23.8
6	-	26	13	23	13	21	22.6	23.8
7	-	26	13	19	10	20	22.1	23.8
8	-	28	11	21	12	21	22.0	23.6
9	-	30	13	21	8	21	21.8	23.5
10	-	32	12	8	12	22	22.2	23.6
11	-	31	12	11	13	27	22.4	23.4
12	-	33	15	14	15	24	22.8	23.5
13	-	34	14	9	9	25	23.3	23.6
14	-	33	15	8	7	25	23.5	23.7
15	-	32	15	7	7	25	23.6	23.8
16	-	33	13	6	9	24	23.7	23.9
17	-	32	15	8	7	24	23.8	24.0
18	-	31	17	11	7	24	24.0	24.0
19	-	31	15	14	8	23	24.0	24.0
20	-	30	15	39	9	23	24.9	24.1
21	-	29	15	9	8	23	23.5	24.2
22	-	31	15	8	6	23	23.4	24.2
23	-	30	15	10	6	23	23.5	24.2
24	-	29	16	10	7	23	23.6	24.2
25	-	30	15	9	7	23	23.6	24.0
26	-	31	14	12	11	24	23.6	24.0
27	-	32	15	9	9	24	23.5	24.1
28	-	33	17	7	7	25	24.1	24.3

Table 33

Weather records for MARCH 1977

Days of the month	Rain-fall (mm)	Max. Temp. (°C)	Min. Temp. (°C)	Rel. Hum. 10 a.m. (%)	Rel. Hum. 4 p.m. (%)	Soil temperature °C at 2"	1ft	4ft.
1	-	32	17	10	9	25	24.4	24.3
2	-	31	18	16	9	26	24.8	24.3
3	-	28	17	21	13	25	24.9	24.4
4	-	25	16	19	14	25	24.6	24.5
5	-	25	17	10	10	23	24.0	24.5
6	-	28	16	14	11	23	23.7	24.5
7	-	31	18	6	6	24	23.8	24.5
8	-	31	18	12	7	24	24.1	24.5
9	-	32	18	9	8	25	24.3	24.5
10	-	33	17	11	9	25	24.9	24.5
11	-	32	17	12	9	25	24.7	24.5
12	-	32	18	11	7	25	24.7	24.5
13	-	32	20	9	8	27	25.0	24.5
14	-	34	20	4	7	26	25.1	24.6
15	-	33	22	5	9	27	25.5	24.7
16	-	33	22	14	8	24	26.1	24.8
17	-	30	19	15	13	26	25.7	24.9
18	-	31	18	11	7	25	25.3	25.2
19	-	31	18	17	11	26	25.2	25.1
20	-	32	19	13	7	25	25.1	25.0
21	-	34	20	13	17	26	25.7	25.0
22	-	36	20	11	11	28	25.2	25.0
23	-	37	19	9	2	29	26.4	25.0
24	-	36	19	14	11	30	26.5	25.1
25	-	34	20	7	7	29	26.9	25.2
26	-	35	20	9	7	31	26.8	25.4
27	-	35	19	10	7	30	26.8	25.4
28	-	36	18	10	24	30	27.0	25.6
29	-	35	19	49	26	31	27.4	25.6
30	-	34	22	53	30	31	28.0	25.7
31	Trace	32	24	66	40	29	28.4	25.8

Table 34

Weather records for APRIL 1977

Days of the month	Rain-fall (mm)	Max. Temp. (°C)	Min. Temp. (°C)	Rel. Hum. 10 a.m. (%)	Rel. Hum. 4 p.m. (%)	Soil temperature °C at 2"	1ft	4ft.
1	-	35	20	25	19	30	27.5	25.9
2	-	35	21	46	15	24	27.3	26.0
3	-	34	22	15	13	30	27.4	26.0
4	-	34	20	15	13	30	27.5	26.1
5	-	36	19	13	11	31	27.8	26.2
6	-	37	22	11	13	31	27.8	26.2
7	-	37	21	12	13	31	28.0	26.3
8	-	37	18	25	15	32	28.4	26.1
9	-	37	18	21	14	32	28.4	26.3
10	-	37	17	41	16	32	28.3	26.6
11	-	38	17	38	14	30	28.4	26.5
12	-	39	16	33	1	33	28.8	26.6
13	-	38	19	56	12	33	29.0	26.7
14	-	37	19	16	0	31	29.3	26.8
15	-	38	22	14	7	32	28.7	27.0
16	-	37	21	11	7	34	29.0	27.0
17	-	37	21	9	9	33	29.0	27.0
18	-	39	20	11	10	32	29.0	27.1
19	-	39	20	25	10	34	29.4	27.2
20	-	39	21	29	10	33	29.8	27.3
21	-	39	22	47	21	34	30.0	27.3
22	-	39	24	46	19	35	30.4	27.4
23	-	32	26	44	24	38	31.2	27.2
24	-	34	26	22	11	31	31.3	27.7
25	-	34	24	19	24	32	30.0	27.7
26	-	36	23	15	14	32	30.0	27.8
27	-	37	21	10	11	33	29.9	27.8
28	-	36	22	48	11	34	29.9	27.9
29	-	37	19	29	9	33	30.1	28.1
30	-	35	22	52	51	34	30.2	28.0

Table 35

Weather records for MAY 1977

Days of the month	Rain-fall (mm)	Max. Temp. (°C)	Min. Temp. (°C)	Rel. Hum. 10 a.m. (%)	Rel. Hum. 4 p.m. (%)	Soil 2"	remperature 1ft	°C at 4ft.
1	10.7	35	19	52	87	34	30.6	28.0
2	-	35	20	61	32	29	29.3	28.4
3	-	37	22	43	21	31	29.1	28.3
4	-	37	21	50	25	32	29.3	28.2
5	Trace	34	21	59	44	33	30.0	28.3
6	5.2	36	22	50	32	33	30.2	28.3
7	-	36	22	47	27	30	29.5	28.2
8	-	31	21	68	45	29	29.2	28.2
9	10.2	34	22	54	35	32	29.0	28.3
10	-	36	20	63	34	29	28.4	28.3
11	-	33	22	56	41	28	28.2	28.2
12	-	33	22	65	39	30	28.4	28.1
13	2.2	35	23	60	32	33	29.0	28.0
14	-	36	21	54	22	32	29.0	28.0
15	-	36	20	23	14	32	28.8	28.0
16	-	37	20	49	20	33	28.8	28.1
17	-	36	23	53	35	34	29.6	28.0
18	-	34	25	63	44	34	30.4	28.1
19	0.1	34	24	53	45	34	30.9	28.2
20	-	35	21	49	39	32	30.0	28.2
21	-	35	22	51	36	35	30.7	27.2
22	-	35	22	50	35	34	31.2	28.3
23	2.8	33	22	62	42	34	31.2	28.6
24	0.1	33	22	64	43	31	30.6	28.7
25	-	34	21	52	37	33	29.9	28.7
26	8.8	35	22	63	41	34	30.6	28.7
27	-	29	14	81	66	28	30.2	28.8
28	2.3	34	20	78	42	27	28.6	28,7
29	2.3	33	20	79	46	22	28.3	28.5
30	25.5	33	21	69	50	30	28.3	28.6
31	8.1	32	17	75	57	30	28.1	28.6

Table 36

Weather records for JUNE 1977

Days of the month	Rain-fall (mm)	Max. Temp. (°C)	Min. Temp. (°C)	Rel. Hum. 10 a.m. (%)	Rel. Hum. 4 p.m. (%)	Soil temperature °C at 2"	1ft.	4ft.
1	-	33	20	66	50	29	27.2	28.4
2	1.5	33	22	69	53	30	28.2	28.4
3	25.6	30	21	76	75	29	28.4	28.3
4	-	28	18	69	74	27	27.0	26.2
5	2.0	31	20	74	58	27	26.5	28.0
6	24.9	33	22	69	54	30	27.3	28.1
7	-	31	18	89	61	25	27.3	27.9
8	-	31	22	77	89	29	27.2	27.8
9	-	33	21	62	52	29	27.4	27.7
10	-	32	21	74	59	28	27.8	27.9
11	4.9	31	23	72	9	29	27.8	27.6
12	3.5	32	19	70	50	28	27.3	27.7
13	10.9	30	18	82	61	27	27.3	27.8
14	-	28	18	86	71	26	26.4	27.7
15	-	31	21	78	60	26	26.3	27.7
16	-	32	21	69	59	29	26.6	27.5
17	7.2	31	22	73	58	28	27.3	27.4
18	8.8	30	18	87	-	29	27.2	27.5
19	-	30	18	87	65	24	26.6	27.5
20	-	29	20	81	71	25	26.3	27.4
21	-	31	21	76	53	27	26.4	27.3
22	-	31	23	67	57	30	26.9	27.2
23	3.4	30	22	67	59	71	27.4	27.2
24	5.7	30	20	77	58	29	27.2	27.2
25	-	32	17	78	48	29	26.7	27.3
26	-	31	20	58	48	30	27.3	26.8
27	-	31	21	67	53	30	27.0	27.1
28	1.0	29	22	68	58	31	27.6	27.2
29	-	28	20	81	67	27	27.3	27.2
30	2.3	29	21	77	54	29	27.0	27.3

APPENDIX II

Worm counts of individual helminth-free tracer lambs grazed for four weeks on pasture in the Northern Guinea Savanna Zone of Nigeria.

Table 37

Worm counts of tracer lambs on pasture in July, 1976

Animal No.	*Haemonchus* spp				*Trichostrongylus* spp				*Cooperia* spp	*Impalaia* spp	*Oesophagastomum* spp	*Strongyloides* spp
	Adult	L_5	L_4	L_3	Adult	L_5	L_4	L_3				
531	1600	2100	1100	0	5100	400	100	200	0	0	0	400
536	3700	2700	5600	100	14700	100	1400	140	0	0	20	100
1138	200	500	1100	0	4400	1700	200	1000	0	0	10	0
1336	3600	6000	5600	0	5800	1100	300	300	0	0	0	100
1340	2800	6600	9800	0	6400	2100	700	800	0	0	100	300

Table 38

Worm counts of tracer lambs on pasture in August 1976.

Animal No.	Haemonchus spp				Trichostrongylus spp				Cooperia spp	Impalaia sp	Oesophagastomum spp	Strongyloides spp
	Adult	L_5	L_4	L_3	Adult	L_5	L_4	L_3				
567	300	0	7200	0	8500	100	0	700	0	0	0	200
1136	100	1600	25100	0	9900	900	300	5800	100	100	200	0
1335	400	5000	6300	0	2000	100	100	900	0	0	200	100

Table 39

Worm counts of tracer lambs on pasture in September 1976.

Animal No.	*Haemonchus* spp				*Trichostrongylus* spp				*Cooperia* spp	*Impalaia* spp	*Oesophagastomum* spp	*Strongyloides* spp
	Adult	L_5	L_4	L_3	Adult	L_5	L_4	L_3				
1000	0	100	1800	100	0	200	400	0	0	0	100	0
1200	500	0	1500	0	6600	0	400	100	0	0	50	0
1382	1300	500	2400	0	3000	200	0	400	0	0	50	0

Table 40

Worm counts of tracer lambs on pasture in October, 1976

Animal No.	Haemonchus spp				Trichostrongylus spp				Cooperia spp	Impalaia spp	Oesophagostomum spp	Strongyloides spp
	Adult	L_5	L_4	L_3	Adult	L_5	L_4	L_3				
457	0	0	11300	0	4200	300	0	1000	0	0	20	0
1001	600	0	17000	0	3500	700	400	3300	0	0	200	100
2476	1100	0	16600	0	4900	700	0	100	0	0	0	0
2432	500	200	25700	0	4800	600	300	2500	200	0	50	0
2437	0	0	11500	0	4000	100	0	300	0	0	0	0
2439	150	0	7050	0	3400	0	0	1800	0	0	20	2900

Table 41

Worm counts of tracer lambs on pasture in November, 1976

Animal No.	Haemonchus spp				Trichostronylus spp				Cooperia spp	Oesophagostomum spp	Strongyloides spp
	Adult	L_5	L_4	L_3	Adult	L_5	L_4	L_3			
2431	0	0	3200	0	3200	0	0	500	0	400	0
2442	40	0	2600	0	2500	0	0	800	0	0	0

Table 42

Worm counts of tracer lambs on pasture in December, 1976

Animal No.	Haemonchus spp				Trichostrongylus spp				Cooperia spp	Oesophagostomum spp	Strongyloides spp
	Adult	L_5	L_4	L_3	Adult	L_5	L_4	L_3			
231	0	0	500	0	200	0	0	0	0	0	0
739	0	0	900	0	300	0	0	200	0	0	0

Table 43

Worm counts of tracer lambs on pasture in January, 1977

Animal No.	Haemonchus spp				Trichostronylus spp				Cooperia spp	Impalaia spp	Oesophagostomum spp	Strongyloides spp
	Adult	L_5	L_4	L_3	Adult	L_5	L_4	L_3				
280	0	0	0	0	0	0	0	0	0	0	0	0
281	0	0	0	0	0	0	0	0	0	0	0	0

Table 44

Worm counts of tracer lambs on pasture in February, 1977

Animal No.	Haemonchus spp				Trichostrongylus spp				Cooperia spp	Impalaia spp	Oesophagostomum spp	Strongyloides spp
	Adult	L_5	L_4	L_3	Adult	L_5	L_4	L_3				
282	0	0	0	0	0	0	0	0	0	0	0	0
284	0	0	0	0	0	0	0	0	0	0	0	0

Table 45

Worm counts of tracer lambs on pasture in March, 1977

Animal No.	Haemonchus spp				Trichostrongylus spp				Cooperia spp	Impalaia spp	Oesophagostomum spp	Strongyloides spp
	Adult	L_5	L_4	L_3	Adult	L_5	L_4	L_3				
1066	0	0	0	0	0	0	0	0	0	0	0	0
1067	0	0	0	0	0	0	0	0	0	0	0	0

Table 46

Worm counts of tracer lambs on pasture in April, 1977

Animal No.	Haemonchus spp				Trichostrongylus spp				Cooperia spp	Impalaia spp	Oesophagostomum spp	Strongyloides spp
	Adult	L_5	L_4	L_3	Adult	L_5	L_4	L_3				
1285	0	0	0	0	0	0	0	0	0	0	0	0
1286	0	0	0	0	0	0	0	0	0	0	0	0

Table 47

Worm counts of tracer lambs on pasture in May, 1977

Animal No.	Haemonchus spp				Trichostrongylus spp				Cooperia spp	Impalaia spp	Oesophagostomum spp	Strongyloides spp
	Adult	L_5	L_4	L_3	Adult	L_5	L_4	L_3				
35	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0

Table 48

Worm counts of tracer lambs on pasture in June, 1977

Animal No.	*Haemonchus* spp				*Trichostrongylus* spp				*Cooperia* spp	*Impalaia* spp	*Oesophagostomum* spp	*Strongyloides* spp
	Adult	L_5	L_4	L_3	Adult	L_5	L_4	L_3				
38	800	1900	0	0	2600	200	0	0	0	0	0	300
39	1000	1200	100	0	1500	800	400	100	0	0	0	100

APPENDIX III

Worm counts of individual sheep used in the study of Inhibited development of trichostrongylids.

Table 49

Worm counts of sheep withdrawn from pasture and housed in June 1976

	Haemonchus spp			Trichostrongylus spp		
	Adult	develop. stages	EL_4	Adult	develop. stages	L_3
Ewes	350	1450	50	7900	0	500
	0	100	25	1325	25	125
	125	75	0	1275	0	400
	25	200	25	10600	100	400
	100	400	0	1450	100	400
permanent lambs	700	625	50	350	0	0
	163	349	0	1325	13	188
	0	0	0	3160	210	530
	1330	730	110	310	0	70
	3800	3800	100	7300	100	0

Table 50

Worm counts of sheep withdrawn from pasture and housed in July 1976

	Haemonchus spp			*Trichostrongylus* spp		
	Adult	develop. stages	EL_4	Adult	develop. stages	L_3
Ewes	0	700	0	8250	0	850
	150	650	100	2300	200	450
	2800	3650	950	24500	0	600
	1500	2900	200	1800	100	500
	750	900	200	4850	300	100
Permanent lambs	2800	1700	700	2200	300	100
	50	1350	0	2600	0	0
	3200	700	200	1900	0	300
	1350	150	0	1600	0	100
	2700	8400	2000	5900	1400	1600
Tracer lambs	1600	2100	1100	5100	500	200
	3700	2800	5600	14700	1500	1400
	200	500	1100	4400	1900	1000
	3600	6000	5600	5800	1400	300
	2800	6600	9800	6400	2800	800

Table 51

Worm counts of sheep withdrawn from pasture and housed in August 1976

	Haemonchus spp			Trichostrongylus spp		
	Adult	develop. stages	EL_4	Adult	develop. stages	L_3
Ewes	600	1000	7200	23000	400	1100
	1000	200	3000	11200	200	600
	1000	700	3400	12400	200	600
	0	1000	5600	7200	0	300
	300	1800	1400	6600	200	2200
Permanent lambs	1700	7000	8000	11500	3000	3300
	3600	1100	4400	10700	500	500
	1200	1100	4500	9500	100	200
	5100	100	1700	13200	700	3900
	2200	1400	2500	8400	400	0
Tracer lambs	300	0	7200	8500	100	700
	100	1600	25100	9900	1200	5800
	400	5000	6300	2000	200	900

Table 52

Worm counts of sheep withdrawn from pasture and housed in September 1976

	Haemonchus spp			*Trichostrongylus* spp		
	Adult	develop. stages	EL_4	Adult	develop. stages	L_3
Ewes	2300	4900	7900	15800	1400	2900
	0	300	2700	14200	0	600
	0	0	600	6250	200	200
	500	500	6300	13900	700	1900
	50	400	600	7750	600	1350
	200	200	3400	10700	0	200
Permanent lambs	1100	400	4100	9400	200	1700
	300	0	5200	13200	0	400
	3200	100	4500	11300	0	300
	0	0	3100	6000	0	3200
	0	0	15950	17800	200	8000
Tracer lambs	0	200	1800	0	600	0
	500	0	1500	6600	400	100
	1300	500	2400	3000	200	400

Table 53

Worm counts of sheep withdrawn from pasture and housed in October 1976

	Haemonchus spp			*Trichostrongylus* spp		
	Adult	develop. stages	EL_4	Adult	develop. stages	L_3
Ewes	100	0	6200	13500	0	300
	0	0	3050	13800	500	0
	0	0	3200	6200	100	100
	100	300	8000	20200	600	4800
	400	100	9200	19100	0	9400
Permanent lambs	0	0	6500	5800	0	0
	400	200	12400	12200	0	3100
	200	500	14900	14500	0	0
	100	200	7100	5400	0	800
Tracer lambs	0	0	11300	4200	300	1000
	600	400	17000	3500	1100	3300
	1100	0	16600	4900	700	100
	500	200	25700	4800	900	2500
	0	0	11500	4000	100	300
	150	0	7050	3400	0	1800

Table 54

Worm counts of sheep withdrawn from pasture and housed in November 1976

	Haemonchus spp			*Trichostrongylus* spp		
	Adult	developing stages	EL_4	Adult	developing stages	L_3
Ewes	2200	0	12500	15100	300	200
	600	0	8900	34600	1300	6900
	0	0	4900	17000	200	0
	300	0	5400	1900	0	400
	300	0	6000	4000	200	500
Permanent lambs	200	0	3400	12000	700	100
	700	0	7500	9400	200	700
	0	0	10000	9000	400	2000
	500	0	4400	15900	500	500
	700	0	9000	10000	200	800
Tracer lambs	0	0	3200	3200	0	500
	40	0	2600	2500	0	800

Table 55

Worm counts of sheep withdrawn from pasture and housed in December 1976

	Haemonchus spp			*Trichostrongylus* spp.		
	Adult	develop. stages	EL_4	Adult	develop. stages	L_3
Ewes	0	0	3200	2700	0	0
	0	0	4900	800	0	1200
	100	0	4000	21600	0	400
	0	0	9000	18000	0	400
Permanent lambs	400	0	1700	11000	800	900
	0	0	6000	15000	0	2000
	0	0	3200	20000	0	700
Tracer lambs	0	0	500	200	0	0
	0	0	900	300	0	100

Table 56

Worm counts of sheep withdrawn from pasture and housed in January 1977

	Haemonchus spp			Trichostrongylus spp		
	Adult	develop. stages	EL_4	Adult	develop. stages	L_3
Ewes	0	0	7000	9400	0	400
	400	0	14700	25800	0	200
	300	0	10000	4200	0	1000
	0	0	6000	5300	0	100
Permanent lambs	300	0	4500	7700	0	3000
	200	0	11000	6200	0	400
	500	100	20000	6800	0	800
	500	0	15500	10300	0	1500
Tracer lambs	0	0	0	0	0	0
	0	0	0	0	0	0

Table 57

Worm counts of sheep withdrawn from pasture and housed in February 1977

	Haemonchus spp			Trichostrongylus spp		
	Adult	develop. stages	EL_4	Adult	develop. stages	L_3
Ewes	0	0	12000	31500	0	400
	100	0	6100	10500	0	0
	0	0	2600	5000	0	0
	100	0	5200	10100	0	700
Permanent lambs	0	0	9600	8800	0	200
	200	0	10000	12000	400	1100
	200	0	2100	19700	0	1200
Tracer lambs	0	0	0	0	0	0
	0	0	0	0	0	0

Table 58

Worm counts of sheep withdrawn from pasture and housed in March 1977

	Haemonchus spp			Trichostrongylus spp		
	Adult	develop. stages	EL_4	Adult	develop. stages	L_3
Ewes	0	0	2100	1400	0	100
	300	0	7500	2370	0	400
	100	0	3000	25000	200	700
	0	0	2700	7800	0	0
Permanent lambs	500	0	5900	3800	400	900
	300	0	9200	21600	0	1500
	300	0	6700	22500	0	300
	300	200	4300	55000	0	0
Tracer lambs	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0

Table 59

Worm counts of sheep withdrawn from pasture and housed in April 1977

	Haemonchus spp			*Trichostrongylus* spp		
	Adult	develop. stages	EL_4	Adult	develop. stages	L_3
Ewes	100	400	0	6100	800	0
	650	400	900	10100	150	250
	300	0	100	0	0	0
	0	300	600	13800	800	200
	200	1500	1500	13100	0	0
	1000	1300	1000	4300	0	0
Permanent lambs	400	1600	800	2900	700	0
	1200	1400	1900	8000	400	300
	1000	1700	1400	2100	1100	0
	800	1300	600	3200	200	100
Tracer lambs	0	0	0	0	0	0
	0	0	0	0	0	0

Table 60

Worm counts of sheep withdrawn from pasture and housed in May 1977

	Haemonchus spp		$5L_4$	Trichostrongylus spp		L_3
	Adult	develop. stages		Adult	develop. stages	
Ewes	1000	900	500	9000	400	0
	800	800	200	13000	600	100
	600	1100	600	4000	300	0
	900	600	3000	2200	500	400
Tracer lambs	0	0	0	0	0	0
	0	0	0	0	0	0
Permanent lambs	800	800	600	21000	1000	200
	700	900	1200	17000	800	0
	900	1000	900	30000	700	200
	100	1000	300	11000	600	0

Table 61

Worm counts of sheep withdrawn from pasture and housed in June 1977

	Haemonchus spp			*Trichostrongylus* spp		
	Adult	develop. stages	EL_4	Adult	develop. stages	L_3
Ewes	1200	1700	200	3000	1000	100
	800	2000	100	16000	900	0
	1000	1900	400	20000	1700	300
	1100	1300	300	1400	1100	0
Permanent lambs	1300	2000	200	1700	2700	200
	900	2200	700	2100	2300	0
	1400	2900	100	4500	3800	600
	2000	2100	800	21000	1600	100
Tracer lambs	800	1900	0	2600	200	0
	1000	1200	100	1500	1200	100

APPENDIX IV

Analysis of variance for the different developmental stages of Haemonchus spp. and Trichostrongylus spp. in the 3 groups of sheep used for inhibition studies.

Table 62

Analysis of variance for adult Haemonchus spp in the 3 groups of sheep

	Sum of squares	Degrees of freedom	Mean square
Between groups	.101E + 08	2	.509E + 07
Within groups	.123E + 09	148	.833E + 06
Total	.133E + 09	150	-

F = 6.1110 Sig. = .0028 P<.01

Table 63

Analysis of variance for Haemonchus spp. development stages in the 3 groups of sheep

	Sum of squares	Degrees of freedom	Mean square
Between groups	.553E + 07	2	.276E + 07
Within groups	.296E + 09	148	.200E + 07
Total	.302E + 09	150	-

F = 1.3812 Sig. = .2545 P>.05

Table 64

Analysis of variance for inhibited Haemonchus spp larvae in the 3 groups of sheep

	Sum of squares	Degrees of freedom	Mean square
Between groups	.299E + 08	2	.149E + 08
Within groups	.373E + 10	148	.252E + 08
Total	.376E + 10	150	-

F = .5928 Sig. = .5541 P>.05

Table 65

Analysis of variance table for adult Trichostrongylus spp. in the 3 groups of sheep

	Sum of squares	Degrees of freedom	Mean square
Between groups	.190E + 10	2	.952E + 09
Within groups	.855E + 10	148	.577E + 08
Total	.104E + 11	150	-
F = 16.4858	Sig. = 0000	P<.01	

Table 66

Analysis of variance table for Trichostrongylus spp. developmental stages in the 3 groups of sheep

	Sum of squares	Degrees of freedom	Mean square
Between groups	.259E + 07	2	.129E + 07
Within groups	.649E + 08	148	.438E + 06
Total	.675E + 08	150	-

F = 2.9528 Sig. = .0553 P >.05

Table 67

Analysis of variance table for inhibited Trichostrongylus spp larvae in the 3 groups of sheep

	Sum of squares	Degrees of freedom	Mean square
Between groups	•125E + 07	2	•625E + 06
Within groups	•302E + 09	148	•204E + 07
Total	•303E + 09	150	-

F = •3061 Sig. = •7368 P>.05

APPENDIX V

Body weight, Eggs per gram of faeces and worm counts of individual sheep used for drug trials.

Table 68

Weight and helminth egg count of the control sheep in trial 1

Animal Tag No.	Weight before treatment (kg)	Weight after treatment (kg)	1st EPG before treatment	2nd EPG before treatment	1st EPG after treatment	2nd EPG after treatment
1	24	23	320	680	1150	4500
2	22	22	2210	4700	4000	5600
3	27	25	500	1000	3100	800
4	25	23	1310	3800	5400	1130
5	26	24	1500	2200	4000	3710
6	24	22	3000	3700	4600	5100

Table 69

Worms counts of the control sheep in trial 1

Animal Tag	Haemonchus spp					Trichostrongylus spp					Oesophagostomum spp
	L_3	EL_4	LL_4	L_5	Adult	L_3	EL_4	LL_4	L_5	Ad.	Adult
1.	-	-	100	300	100	-	-	-	800	6100	380
2.	-	900	200	200	650	250	-	150	-	10100	940
3.	-	100	-	-	300	-	-	-	-	-	-
4.	-	600	-	300	-	200	-	-	800	13800	160
5.	-	1500	300	1200	200	-	-	-	-	13100	440
6.	-	1000	400	900	1000	-	-	-	-	4300	200

Table 70

Weight and helminth egg count of the group of sheep treated with Nemafax 50 mg./kg. body weight in trial 1

Animal Tag No.	Weight before treatment (kg)	Weight after treatment (kg)	1st EPG before treatment	2nd EPG before treatment	1st EPG after treatment	2nd EPG after treatment
7.	21	22	2450	2110	60	740
8.	25	23	1880	1160	30	90
9.	22	22	510	1550	0	0
10.	23	24	1250	1160	0	0
11.	23	22	1290	800	160	300
12.	24	23	2500	3000	1800	5000

Table 71

Worm counts of the groups of sheep treated with Nemafax 50 mg./kg body weight in trial 1

Animal Tag	Haemonchus spp.					Trichostrongylus spp					Oesophagostomum spp
	L_3	EL_4	LL_4	L_5	Adult	L_3	EL_4	LL_5	LL_5	Adult	Adult
7.	-	-	-	-	-	-	-	-	-	-	220
8.	-	-	-	700	-	-	-	-	-	-	40
9.	-	-	200	-	-	-	-	-	-	-	-
10.	-	-	-	-	-	-	-	-	-	-	-
11.	-	50	100	800	-	-	-	-	-	170	120
12.	-	200	300	600	-	-	-	-	-	1000	-

Table 72

Weight and helminth egg counts of the group of sheep treated with Thiabendazole 50 mg./kg. body weight in trial 1

Animal Tag No.	Weight before treatment (kg).	Weight after treatment (kg)	1st EPG before treatment	2nd EPG before treatment	1st EPG after treatment	2nd EPG after treatment
19.	24.3	25	1720	7220	90	40
20.	23	22	330	1500	0	0
21.	20	20	1150	2480	80	2000
22.	20	21	221	2020	0	0
23.	22	22	2000	1700	1000	4000
24.	24	23	800	1400	150	1200

Table 73

Worm counts of the group of sheep treated with Thiabendazole 50 mg./kg. body weight in trial 1

Animal Tag	Haemonchus spp.					Trichostrongylus spp.					Oesophagostomum spp
	L_3	EL_4	LL_4	L_5	Adult	L_3	EL_4	LL_4	L_5	Adult	
19.	-	-	-	50	-	-	-	-	-	-	10
20.	-	-	-	-	-	-	-	-	-	-	-
21.	-	-	300	300	700	-	-	-	-	-	-
22.	-	100	100	100	-	-	-	-	-	-	-
23.	-	400	500	1200	300	-	-	-	-	1600	100
24.	-	-	-	500	700	-	-	-	-	-	-

Table 74

Weight and helminth egg counts of the group of sheep treated with Nemafax 100 mg./kg. body weight in trial 1

Animal Tag No.	Weight before treatment (kg)	Weight after treatment (kg)	1st EPG before treatment	2nd EPG before treatment	1st EPG after treatment	2nd EPG after treatment
31.	23	20	1640	6480	0	0
32.	25	25	1580	3850	0	0
33.	25	24	1600	5000	0	0
34.	26	24	710	1740	0	0
35.	24	23	2000	4100	0	0
36.	23	22	1700	2900	0	0

Table 75

Worm counts of the group of sheep treated with Nemafax 100 mg./kg. body weight in trial 1

Animal Tag	Haemonchus spp.					Trichostrongylus spp.					Oesophagostomum spp.
	L_3	EL_4	LL_4	L_5	Adult	L_3	EL_4	LL_4	L_5	Adult	Adult
31.	0	0	0	0	0	0	0	0	0	0	0
32.	0	0	0	0	0	0	0	0	0	0	0
33.	0	0	0	0	0	0	0	0	0	0	0
34.	0	0	0	0	0	0	0	0	0	0	0
35.	0	0	0	0	0	0	0	0	0	0	0
36.	0	0	0	0	0	0	0	0	0	0	0

Table 76

Group treated with Thiabendazole 100 mg/kg

Weight and helminth egg counts of the group of sheep treated with Thiabendazole 100 mg/kg. body weight in trial 1

Animal Tag	Weight before treatment (kg)	Weight after treatment (kg)	1st EPG before treatment	2nd EPG before treatment	1st EPG after treatment	2nd EPG after treatment
37.	25.5	25	1090	3500	0	0
38.	24	23	700	2020	0	0
39.	26	24	2110	3110	0	0
40.	26	26	2800	3250	0	0
41.	24	23	1800	3400	0	0
42.	25	25	2200	4000	0	0

Table 77

Worm counts of the group of sheep treated with Thiabendazole 100 mg./kg. body weight in trial 1

Animal Tag	Haemonchus spp.					Trichostrongylus spp.					Oesophagostomum spp
	L_3	EL_4	LL_4	L_5	Adult	L_3	EL_4	LL_4	L_5	Adult	
37.	0	0	0	0	0	0	0	0	0	0	0
38.	0	0	0	0	0	0	0	0	0	0	0
39.	0	0	0	0	0	0	0	0	0	0	0
40.	0	0	0	0	0	0	0	0	0	0	0
41.	0	0	0	0	0	0	0	0	0	0	0
42.	0	0	0	0	0	0	0	0	0	0	0

Table 78

Weight and helminth egg counts of the group of sheep treated with Nemafax 200 mg/kg body weight in trial 1

Animal Tag	Weight before treatment (kg)	Weight after treatment (kg)	1st EPG before treatment	2nd EPG before treatment	1st EPG after treatment	2nd EPG after treatment
13.	22	24	2840	8000	0	0
14.	21	23	6920	4190	0	0
15.	25	26	1200	1540	0	0
16.	22	24	2860	850	0	0
17.	24	25	2100	3280	0	0
18.	26	27	1240	2800	0	0

Table 79

Worm counts of the group of sheep treated with Nemafax 200 mg/kg body weight in trial 1

Animal Tag	Haemonchus spp					Trichostrongylus spp.					Oesophagostomum spp.
	L_3	EL_4	LL_4	L_5	Adult	L_3	EL_4	LL_4	L_5	Adult	
13.	0	0	0	0	0	0	0	0	0	0	0
14.	0	0	0	0	0	0	0	0	0	0	0
15.	0	0	0	0	0	0	0	0	0	0	0
16.	0	0	0	0	0	0	0	0	0	0	0
17.	0	0	0	0	0	0	0	0	0	0	0
18.	0	0	0	0	0	0	0	0	0	0	0

Table 80

Weight and helminth egg counts of the group of sheep treated with Thiabendazole 200 mg/kg body weight in trial 1

Animal Tag No.	Weight before treatment (kg)	Weight after treatment (kg)	1st EPG before treatment	2nd EPG before treatment	1st EPG after treatment	2nd EPG after treatment
25.	24	23	4810	8460	0	0
26.	26	25	1400	1760	0	0
27.	23	21	1200	1780	0	0
28.	26	27	1820	1010	0	0
29.	24	24	4000	5200	0	0
30.	22	23	3200	4700	0	0

Table 81

Worm counts of the group of sheep treated with Thiabendazole 200 mg/kg body weight in trial 1

Animal Tag	Haemonchus spp					Trichostrongylus spp.					Oesophagostomum spp
	L_3	EL_4	LL_4	L_5	Adult	L_3	EL_4	LL_4	L_5	Adult	
25.	0	0	0	0	0	0	0	0	0	0	0
26.	0	0	0	0	0	0	0	0	0	0	0
27.	0	0	0	0	0	0	0	0	0	0	0
28.	0	0	0	0	0	0	0	0	0	0	0
29.	0	0	0	0	0	0	0	0	0	0	0
30.	0	0	0	0	0	0	0	0	0	0	0

Table 82

Weight and helminth egg counts of the control sheep in trial 2

Animal Tag.	Weight before treatment (kg)	Weight after treatment (kg)	EPG before treatment	EPG after treatment
1682	22	21.5	1000	5240
2054	20	20.0	116860	200000
2057	23	22.5	3900	11000
2058	15	14.6	2500	6440
2062	17	16.4	3160	20840
2070	19	18.7	480	4320

Table 83

Worm counts of the control sheep in trial 2

Animal Tag	Haemonchus spp.			Trichostrongylus spp.			Others
	EL_4	Develop. stages	Adult	L_3	Develop. stages	Adult	
1682	6000	1200	800	1000	500	800	0
2054	4000	700	3000	800	300	24000	0
2057	2000	1000	1500	300	300	10200	0
2058	5400	500	1000	600	100	7500	0
2062	3700	800	2000	200	400	15000	0
2070	7000	200	800	500	800	6000	0

Table 84

Weight and helminth egg counts of the group of sheep treated with Nemafax 50 mg/kg body weight in trial 2

Animal Tag	Weight before treatment (kg)	Weight after treatment (kg)	EPG before treatment	EPG after treatment
2019	20	20.0	14700	0
2034	19	18.5	600	0
2052	22	21.7	3440	60
2069	19	18.6	8240	0

Table 85

Worm counts of the group of sheep treated with Nemafax 50 mg/kg body weight in trial 2

Animal Tag	Haemonchus spp.			Trichostrongylus spp.			Others
	EL_4	Develop.	Adult	L_3	Develop.	Adult	
2019	800	200	0	0	600	0	0
2034	500	300	0	100	200	0	0
2052	0	700	100	300	0	200	0
2069	3000	100	0	0	400	0	0

Table 86

Weight and helminth egg counts of the group of sheep treated with Thiabendazole 50 mg/kg body weight in trial 2

Animal Tag	Weight before treatment (kg)	Weight after treatment (kg)	EPG before treatment	EPG after treatment
2018	17	16.4	2020	300
2042	15	15.0	2280	0
2045	19	18.5	1110	520
2059	21	20.5	1420	0

Table 87

Worm counts of the group of sheep treated with Thiabendazole 50 mg/kg body weight in trial 2

Animal Tag	Haemonchus spp.			Trichostrongylus spp.			Others
	EL_4	Develop. stages	Adult	L_3	Develop. stages	Adult	
2018	500	100		100	0	100	0
2042	2000	0		0	0	0	0
2045	1800	250		300	300	250	0
2059	4000	120		0	100	0	0

Table 88

Weight and helminth egg counts of the group of sheep treated with loxon 2 at 25.5 mg/kg

Animal Tag	Weight before treatment (kg)	Weight after treatment (kg)	EPG before treatment	EPG after treatment
2026	18	17.7	31700	4800
2031	15	14.8	1420	1160
2046	19	18.5	7340	1800
2049	15	15.0	3360	1240
2068	21	19.8	1000	10580
2063	18	17.5	4600	3960

Table 89

Worm counts of the group of sheep treated with loxon 2 at 25.5 mg/kg.

Animal Tag	Haemonchus spp.			Trichostrongylus spp.			Others
	EL_4	Develop. stages	Adult	L_3	Develop. stages	Adult	
2026	3500	100	200	300	600	400	0
2031	6000	300	100	0	700	100	0
2046	4000	600	300	400	200	300	0
2049	1200	0	600	100	100	200	0
2068	7000	0	900	0	300	700	0
2063	5100	400	500	0	800	400	0

Table 90

Weight and helminth egg counts of the group of sheep treated with Renide at 7.58 mg/kg.

Animal Tag	Weight before treatment (kg)	Weight after treatment (kg)	EPG before treatment	EPG after treatment
1671	14	13.7	112260	7520
2030	19	18.8	21240	3420
2036	16	15.7	5220	4420
2039	15	14.4	2020	800
2043	16	15.6	760	1960
2067	21	20.0	6200	6160

Table 91

Worm counts of the group of sheep treated with Ramide at 7.58 mg/kg

Animal Tag	*Haemonchus* spp. EL_4	*Haemonchus* spp. Develop. stages	*Haemonchus* spp. Adult	*Trichostrongylus* spp. L_3	*Trichostrongylus* spp. Develop. stages	*Trichostrongylus* spp. Adult	Others
1671	4000	0	100	200	500	800	0
2030	3200	500	300	100	100	400	0
2036	100	200	800	300	300	500	0
2039	6000	100	200	100	300	300	0
2043	1500	100	300	100	100	200	0
2067	2800	600	500	0	200	600	0

Table 92

Weight and helminth egg counts of the group of sheep treated with Nemafex 100 mg/kg body weight in trial 2

Animal Tag	Weight before treatment (kg)	Weight after treatment (kg)	EPG before treatment	EG after treatment
2027	19	19.4	5600	0
2028	18	17.6	12280	0
2033	21	20.5	3240	0
2047	21	20.8	6000	0

Table 93

Worm counts of the group of sheep treated with Nemafax 100 mg/kg. body weight in trial 2

Animal Tag	*Haemonchus* spp.			*Trichostrongylus* spp.			Others
	EL_4	Develop. stages	Adult	L_3	Develop. stages	Adult	
2027	0	0	0	0	0	0	0
2028	0	0	0	0	0	0	0
2033	0	0	0	0	0	0	0
2047	0	0	0	0	0	0	0

Table 94

Weight and helminth egg counts of the group of sheep treated with Thiabendazole 100 mg/kg body weight in trial 2

Animal Tag	Weight before treatment (kg)	Weight after treatment (kg)	EPG before treatment	EPG after treatment
2018	17	16.4	2020	0
2024	15	15	2280	0
2055	19	18.5	22220	0
2059	21	20.5	1420	0

Table 95

Worm counts of the group of sheep treated with Thiabendazole 100 mg/kg body weight in trial 2.

Animal Tag	*Haemonchus spp.*			*Trichostrongylus spp.*			
	EL_4	Develop. stages	Adult	L_3	Develop. stages	Adult	Others
2018	0	0	0	0	0	0	0
2042	0	0	0	0	0	0	0
2055	0	0	0	0	0	0	0
2059	0	0	0	0	0	0	0

Table 96

Weight and helminth egg counts of the group of sheep treated with loxon 2 at 51 mg/kg.

Animal Tag	Weight before treatment (kg)	Weight after treatment (kg)	EPG before treatment	EPG after treatment
2015	17	16.8	2900	840
2037	17	16.4	3540	0
2029	24	23	6020	7960
2048	20	29	1560	2440
2056	23	22.5	4420	0
2066	20	20	4900	560

Table 97

Worm counts of the group of sheep treated with loxon 2 at 51 mg/kg.

Animal Tag	Haemonchus spp. EL_4	Develop. stages	Adult	Trichostrongylus spp. L_3	Develop. stages	Adult	Others
2015	5000	300	300	200	100	300	0
2037	3500	300	0	0	200	0	0
2029	1000	0	700	100	300	600	0
2048	4000	100	400	700	200	500	0
2056	1500	0	0	100	100	0	0
2066	3000	100	200	300	100	200	0

Table 98

Weight and helminth egg counts of the group of sheep treated with Ranide at 15.16 mg/kg.

Animal Tag	Weight before treatment (kg)	Weight after treatment (kg)	EPG before treatment	EPG after treatment
1630	18	17.8	15020	3800
2032	18	17.2	31400	1160
2035	11	11	3000	0
2044	16	15.6	10000	1700
2053	20	19.4	11300	3000
2065	19	18.5	17500	1280

Table 99

Worm counts of the group of sheep treated with Ranide at 15.16 mg/kg.

Animal Tag	Haemonchus spp.			Trichostrongylus spp.			Others
	EL_4	Develop. stages	Adult	L_3	Develop. stages	Adult	
1630	2500	200	500	100	200	700	0
1632	400	800	900	0	300	200	0
1635	800	400	0	0	300	0	0
2044	4000	0	200	400	0	100	0
2053	1000	0	400	300	100	800	0
2065	0	700	100	100	400	300	0

APPENDIX VI

Helminth egg counts per gram of sheep faeces, blood values and worm counts of sheep with acute or chronic helminthiasis.

Table 100

Epg and blood values of sheep 513 with acute helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Esgm. %	Lymph. %	Mono. %
7-6-76	20	28.5	10.1	8.58	7.4	4½	0	0	24	70½	1
14-6-76	70	32.0	9.2	6.57	6.90	-	-	-	-	-	-
21-6-76	290	25.0	8.6	6.67	8.50	5	-	½	29	65½	0
29-6-76	1310	22.0	8.5	5.82	8.90	-	-	-	-	-	-
5-7-76	2320	28.0	8.4	5.91	5.40	8	0	0	28	63½	½
12-7-76	4900	29.5	8.7	6.59	5.50	-	-	-	-	-	-
19-7-76	8110	25.0	8.2	6.19	8.00	10½	0	0	38½	50½	½

Table 101

Epg and blood values of sheep 514 with acute helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl.	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	1780	16.0	4.9	6.42	9.5	2	0	0	53½	44½	0
14-6-76	5150	13.5	4.1	6.61	13.8	-	-	-	-	-	-
21-6-76	3500	10.0	3.4	5.79	11.1	1	0	0	55½	41	2½
5-7-76	4030	9.0	7.8	5.47	8.4	4	0	0	58	38	0
12-7-76	3500	11.5	3.1	2.81	9.4	-	-	-	-	-	-
19-7-76	3220	10.0	2.6	2.23	13.9	0	0	0	74½	25½	0

Table 102

Epg and blood values of sheep 533 with acute helminthiasis

DATE	EPG.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^6/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	0	15.0	5.3	4.57	5.00	1	0	0	54	44	1
14-6-76	20	17.0	5.7	4.53	6.60	-	-	-	-	-	-
21-6-76	950	18.0	5.4	5.15	4.70	3½	0	1	30½	65	0
29-6-76	1500	18.0	9.5	4.14	4.60	-	-	-	-	-	-
5-7-76	3480	15.5	5.3	3.65	5.90	3	0	0	42½	52	2½
12-7-76	3790	11.5	3.8	3.34	4.00	-	-	-	-	-	-
19-7-76	5450	11.0	3.9	3.90	9.00	½	0	0	59	38½	2

Table 103

Epg and blood values of sheep 552 with acute helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	0	22.0	7.1	6.72	4.2	½	0	0	8½	87	4
14-6-76	20	20.5	6.7	6.41	11.6	-	-	-	-	-	-
12-6-76	3500	18.0	6.4	5.70	12.6	½	0	0	55½	38	1½
29-6-76	950	16.5	5.2	4.77	7.5	-	-	-	-	-	-
5-7-76	5730	15.0	5.1	3.65	14.4	7½	0	0	56½	33½	2½
12-7-76	5500	14.0	4.9	4.00	7.4	-	-	-	-	-	-
19-7-76	7220	14.0	5.0	4.50	11.6	5½	0	0	49½	45	0

Table 104

Epg. and blood values of sheep 553 in acute helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono %
7-6-76	0	15.0	5.7	5.75	8.3	3	0	0	56	39	2
14-6-76	0	18.0	5.4	6.23	9.9	-	-	-	-	-	-
21-6-76	390	15.0	4.8	6.65	7.7	4	0	0	76	18½	1½
29-6-76	1460	13.0	4.2	5.76	7.2	-	-	-	-	-	-
5-7-76	2300	11.5	3.9	3.26	8.6	1	0	0	62½	36	½
12-7-76	3200	12.0	4.1	3.38	9.2	-	-	-	-	-	-
19-7-76	4400	11.0	3.4	3.03	7.8	5	0	0	64	31½	0

Table 105

Epg and blood values of sheep 558 in acute helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	0	30.0	11.1	10.50	19.9	2	0	0	52	46	0
14-6-76	420	30.0	11.0	10.20	16.1	-	-	-	-	-	-
21-6-76	420	26.0	9.5	9.08	14.0	2½	0	0	58	40	0
29-6-76	800	19.0	7.0	6.47	11.2	-	-	-	-	-	-
5-7-76	2370	13.0	5.0	4.12	4.0	8½	0	0	63	28½	0
12-7-76	7500	15.5	5.4	3.98	15.5	-	-	-	-	-	-
19-7-76	12800	12.0	4.8	3.92	18.1	2	0	0	54½	44	0

Table 106

Epg and blood values of sheep 577 in acute helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	0	31.0	10.4	9.94	9.5	0	0	0	47½	50½	2
14-6-76	600	26.5	9.0	8.32	14.2	-	-	-	-	-	-
21-6-76	490	21.0	7.8	8.59	9.2	½	0	0	56	42	1
29-6-76	700	18.0	6.0	5.64	9.7	-	-	-	-	-	-
5-7-76	1270	15.0	4.8	4.51	12.8	0	0	3	75	72	0

Table 107

Epg and blood values of sheep 594 in acute helminthiasis

DATE	Egp.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC 10^3/cmm	Eosin %	Baso. %	Band %	Segm. %	Lymph %	Mono. %
7-6-76	0	32.0	12.8	9.39	13.3	3½	0	0	26	69½	0
14-6-76	30	29.5	12.9	10. 6	15.2	-	-	-	-	-	-
21-6-76	870	26.0	11.4	10.63	15.7	3½	0	0	36½	59	1
29-6-76	900	27.0	12.2	7.79	10.4	-	-	-	-	-	-
5-7-76	1580	Clotted	-	-	-	1½	0	0	28½	69½	½
12-7-76	1160	20.5	7.8	6.26	8.3	-	-	-	-	-	-
19-7-76	9680	16.5	6.7	5.64	8.3	0	0	0	50½	49½	0
26-7-76	10460	13.0	4.6	4.75	15.0	-	-	-	-	-	-

Table 108

Epg and blood values of sheep 1105 in acute helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono %
7-6-76	0	23.5	9.0	8.11	8.9	1	0	0	46	43	1
14-6-76	0	26.5	9.2	9.06	7.1	-	-	-	-	-	-
21-6-76	470	24.0	8.6	8.19	6.6	3	0	0	26	69	2
29-6-76	1300	22.0	8.7	5.64	6.8	-	-	-	-	-	-
5-7-76	11340	17.0	6.4	6.32	5.7	½	0	0	37	62½	0
12-7-76	7100	16.0	5.5	3.94	5.2	-	-	-	-	-	-
19-7-76	2930	9.5	2.6	2.76	12.7	0	0	0	70½	28	1½

Table 109

Epg and blood values of sheep 1114 in acute helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph %	Mono %
7-6-76	0	25.0	9.2	8.66	10.40	½	0	0	44½	54½	½
14-6-76	60	25.5	10.0	9.21	15.00	-	-	-	-	-	-
21-6-76	50	22.0	8.6	8.80	12.10	1	0	0	42½	52½	4
29-6-76	1310	20.0	7.0	5.77	10.70	-	-	-	-	-	-
5-7-76	1500	19.5	6.8	5.32	12.50	1½	0	2	66½	29½	½
12-7-76	2910	17.0	6.0	4.50	9.50	-	-	-	-	-	-
19-7-76	2770	14.0	4.9	4.34	15.10	½	0	0	58½	41½	0

Table 110

Epg and blood values of sheep 1116 in acute helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono %
7-6-76	0	34.5	13.1	10.94	15.7	1	0	0	38	61	0
14-6-76	0	34.0	12.2	10.59	13.4	-	-	-	-	-	-
21-6-76	180	34.0	11.6	10.33	11.9	1½	0	0	28	69	1½
29-6-76	900	34.0	13.2	10.42	11.1	-	-	-	-	-	-
5-7-76	2140	32.0	11.6	10.29	11.3	½	0	1	26½	71	1
12-7-76	6450	21.0	7.7	6.99	8.1	-	-	-	-	-	-
19-7-76	11480	21.5	7.5	5.77	6.9	½	0	0	34	65	½

Table 111

Epg and blood values of sheep 1117 in acute helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono %
7-6-76	0	22.5	8.6	9.11	5.00	½	0	0	46	50½	1½
14-6-76	0	25.0	11.5	10.96	13.4	-	-	-	-	-	-
21-6-76	200	18.0	6.0	7.85	7.30	½	0	½	65	33½	½
29-6-76	1320	19.0	7.1	7.60	6.30	-	-	-	-	-	-
5-7-76	2130	20.5	7.0	6.44	16.60	0	0	0	76½	22½	1
12-7-76	2370	14.0	5.8	4.76	10.70	-	-	-	-	-	-
19-7-76	11350	11.5	4.3	3.75	11.00	1	0	0	61	36	2

Table 114

Epg and blood values of sheep 1124 in acute helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono %
7-6-76	0	32.5	9.9	10.04	11.2	11½	0	0	47½	51	0
14-6-76	0	26.0	8.8	7.81	9.7	-	-	-	-	-	-
21-6-76	200	23.0	7.9	7.31	9.6	5	0	0	42	53	0
29-6-76	1000	22.0	9.6	6.90	13.6	-	-	-	-	-	-
5-7-76	7580	17.0	6.3	5.64	11.4	3	0	0	52½	44	½
12-7-76	5890	13.0	4.5	3.62	9.1	-	-	-	-	-	-

Table 112

Epg and blood values of sheep 1118 in acute helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono %
7-6-76	0	28.5	10.3	10.36	9.30	2	0	0	46	50½	1½
14-6-76	0	26.0	10.0	9.23	8.00	-	-	-	-	-	-
21-6-76	20	24.0	9.1	8.86	7.10	4½	0	0	34½	60	1
29-6-76	1400	25.0	8.6	7.36	6.20	-	-	-	-	-	-
12-7-76	1080	16.0	5.9	4.29	11.90	-	-	-	-	-	-
19-7-76	2280	12.0	4.0	2.91	8.90	0	0	0	62½	35	2½

Table 115

Epg and blood values of sheep 1126 in acute helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono %
7-6-76	0	29.0	11.8	10.45	11.8	0	0	0	57½	41½	1
14-6-76	0	24.5	8.9	8.66	11.2	-	-	-	-	-	-
21-6-76	120	24.0	8.0	8.27	12.5	1	0	0	56½	41	1½
29-6-76	800	24.0	8.9	7.79	11.1	-	-	-	-	-	-
5-7-76	1650	23.5	8.8	7.20	9.9	1	0	½	60	37	1½
12-7-76	2540	20.5	7.6	6.31	11.3	-	-	-	-	-	-
19-7-76	2730	14.5	5.1	4.52	11.3	0	0	½	68½	31½	0

Table 116

Epg and blood values of sheep 1128 in acute helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	0	30.5	10.9	10.43	8.90	0	0	0	40	57½	2½
14-6-76	0	31.5	11.0	10.50	11.53	-	-	-	-	-	-
21-6-76	910	26.0	9.6	9.80	7.40	0	0	0	49½	49	1½
29-6-76	800	20.0	7.8	8.27	9.60	-	-	-	-	-	-
5-7-76	3950	21.5	7.4	6.38	7.30	½	0	0	43	56½	0
12-7-76	6400	20.0	6.5	4.77	6.90	-	-	-	-	-	-
19-7-76	11840	14.0	4.2	3.30	8.10	0	0	0	63½	35	1½

Table 117

Epg and blood values of sheep 1137 in acute helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono %
7-6-76	0	33.0	12.0	10.11	12.20	0	0	0	65	34	1
14-6-76	0	35.0	11.9	10.96	21.80	-	-	-	-	-	-
21-6-76	860	28.0	10.4	10.72	15.00	1	0	0	63	35	1
29-6-76	1550	26.0	9.3	8.10	8.90	-	-	-	-	-	-
5-7-76	4580	13.5	4.9	4.40	7.60	0	0	0	$68\frac{1}{2}$	24	$4\frac{1}{2}$

Table 118

Epg and blood values of sheep 1139 in acute helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono %
7-6-76	0	31.0	12.6	10.3	8.89	1½	0	0	63	34	1½
14-6-76	0	39.5	14.3	9.44	11.00	-	-	-	-	-	-
21-6-76	670	30.0	11.9	9.70	11.60	1	0	0	44½	52½	2
29-6-76	1400	29.0	9.9	8.30	8.00	-	-	-	-	-	-
5-7-76	2730	24.0	8.6	6.59	7.10	½	0	0	38	60	½
12-7-76	3800	22.0	8.1	8.00	8.60	-	-	-	-	-	-
19-7-76	6050	19.0	6.6	5.96	9.30	2½	0	0	52½	44½	½

Table 119

Epg and blood values of sheep 1149 in acute helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono %
7-6-76	0	29.0	11.6	9.36	8.5	1½	0	0	59½	37½	1½
14-6-76	0	33.1	12.7	10.00	9.4	-	-	-	-	-	-
12-6-76	200		Clotted		-	-	-	-	-	-	-
29-6-76	1600	30.0	12.0	6.34	7.5	-	-	-	-	-	-
5-7-76	1810	25.0	9.4	8.15	7.1	1½	0	0	50	47½	1
12-7-76	4300	19.0	7.1	6.80	7.1	-	-	-	-	-	-
19-7-76	6960	18.1	6.6	5.80	7.1	5	0	0	48½	47½	0

Table 120

Epg and blood values of sheep 1152 in acute helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	0	39.0	15.2	10.96	11.5	0	0	0	40½	59½	0
14-6-76	0	42.5	14.9	7.36	8.3	-	-	-	-	-	-
21-6-76	120	38.0	14.3	7.93	9.2	0	0	0	40	58½	1½
29-6-76	1200	39.0	10.9	6.37	5.6	-	-	-	-	-	-
5-7-76	1600	39.0	13.3	10.84	8.4	3½	0	0	28½	67½	½
12-7-76	2990	32.0	10.9	8.94	11.5	-	-	-	-	-	-
19-7-76	-	Clotted	-	-	-	-	-	-	-	-	-

Table 121

Epg and blood values of sheep 1153 in acute helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
8-6-76	0	34.5	12.5	10.94	12.2	1	0	0	42	53	1
14-6-76	0	34.0	13.1	8.04	5.8	-	-	-	-	-	-
21-6-76	260	28.0	11.5	8.82	11.1	0	0	1½	25½	73	1
29-6-76	1510	27.0	10.1	9.57	13.1	-	-	-	-	-	-
5-7-76	3120	22.5	7.4	6.52	8.5	1½	0	½	36½	60	1½
12-7-76	5500	16.5	6.2	6.08	10.5	-	-	-	-	-	-
19-7-76	3510	16.0	5.7	4.49	5.1	0	0	0	53	45	2

Table 122

Epg and blood values of sheep 1156 in acute helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	0	35.5	12.5	10.94	12.2	2	0	0	51	43½	3½
14-6-76	0	32.5	11.7	10.00	12.6	-	-	-	-	-	-
21-6-76	0	25.0	10.6	10.09	10.6	1½	0	0	44	52	2½
29-6-76	1400	21.0	7.3	6.44	7.7	-	-	-	-	-	-
5-6-76	6040	14.0	4.8	3.41	7.6	1½	0	0	56½	41½	1

Table 123

Worms recovered from the group of sheep with acute infection

No.	Haemonchus spp.		Trichostrongylus spp.		Strongyloides spp.	Others
	Adult	Immature	Adult	Immature		
513	2000	800	3200	1000	3100	0
514	1400	2000	1500	600	400	0
533	2600	800	1000	1700	0	0
552	1750	450	950	1250	100	100
553	1800	300	2200	400	800	0
558	1000	8000	4800	200	600	0
577	1500	1400	3000	0	1100	400
594	3000	6000	1800	0	450	200
1105	1340	3100	1600	600	100	100
1114	2000	800	5100	900	1800	100
1116	1600	900	4400	100	300	0
1117	3700	1700	6400	6400	2200	100
1118	4100	1100	5800	1600	1300	300
1119	2100	800	1900	1000	900	0
1124	1800	400	1600	800	100	200
1126	1000	2500	2100	400	500	100
1128	1400	900	800	0	400	0
1137	2500	900	1500	500	700	0
1139	1600	1300	14600	1300	1300	0
1149	3200	300	8100	400	2100	200
1152	11550	750	11500	1600	600	600
1153	900	1100	9000	900	1100	300
1156	1800	1200	2300	0	300	100

Table 124

Epg and blood values of sheep 495 with chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono %
7-6-76	140	28.0	10.4	9.74	8.8	7	0	0	60½	31	1½
14-6-76	10	30.5	10.6	10.02	11.0	-	-	-	-	-	-
21-6-76	190	28.5	10.7	10.32	14.1	5½	0	0	48	46½	0
29-6-76	70	21.0	11.4	10.14	14.1	-	-	-	-	-	-
5-7-76	290	29.5	10.0	8.76	8.2	6	0	0	26	68	0
12-7-76	320	29.5	10.7	9.53	12.5	-	-	-	-	-	-
19-7-76	800	27.5	9.9	7.76	12.9	12½	0	½	41½	44	1½
26-7-76	1210	27.0	10.5	9.62	15.3	-	-	-	-	-	-
3-8-76	1210	26.5	10.4	8.38	6.8	10	0	0	41½	45	3½
9-8-76	1390	28.5	10.1	9.34	16.1	-	-	-	-	-	-
16-8-76	1900	26.5	9.4	9.69	11.2	6	0	0	26	66	2
23-8-76	2850	23.5	7.8	7.01	11.1	-	-	-	-	-	-
30-8-76	150	23.0	7.9	7.12	12.9	10	0	½	44	43½	2
6-9-76	3270	23.0	6.8	6.96	11.4	-	-	-	-	-	-
13-9-76	4840	23.0	7.7	6.95	11.9	2½	0	0	28½	67½	1½
20-9-76	7800	22.5	6.0	5.50	7.1		-	-	-	-	-

Table 125

Epg and blood values of sheep 499 in chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	0	22.0	8.5	7.84	7.4	5½	0	0	30	62½	1
14-6-76	120	29.5	11.2	10.33	14.4	-	-	-	-	-	-
21-6-76	240	29.0	8.4	8.23	8.9	8½	0	0	36½	55	0
29-6-76	350	28.0	9.2	8.60	9.7	-	-	-	-	-	-
5-7-76	410	27.0	10.2	7.44	10.9	12½	0	0	48	38½	1
12-7-76	300	25.0	9.4	8.02	8.7	-	-	-	-	-	-
19-7-76	120	26.0	9.4	8.19	12.6	12	0	0	58	28	2
26-7-76	1340	24.0	10.7	7.92	12.2	-	-	-	-	-	-
3-8-76	570	23.0	8.9	7.07	9.3	5½	0	0	43	50	1½
9-8-76	1360	24.0	9.0	6.95	7.2	-	-	-	-	-	-
16-8-76	1240	22.5	8.2	7.78	10.6	9	0	0	38	49½	3½
23-8-76	11100	21.5	8.1	7.26	9.8	-	-	-	-	-	-
30-8-76	1050	20.5	6.4	8.23	12.8	14	0	0	31	53	2
6-9-76	4470	21.0	8.1	7.72	12.4	-	-	-	-	-	-
13-9-76	1700	21.0	6.9	6.32	10.3	13	0	0	40	45	2
20-9-76	900	23.0	6.4	6.26	10.8	-	-	-	-	-	-
4-9-76	5320	20.0	6.2	6.03	8.3	-	-	-	-	-	-

Table 126

Epg and blood values of sheep 500 with chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	26	30.0	11.4	9.32	12.5	12	0	1	35	46	1
14-6-76	670	33.5	11.5	9.90	11.1	-	-	-	-	-	-
21-6-76	160	32.0	10.8	9.57	7.9	5	0	0	36	57	2
29-6-76	90	31.0	11.0	9.54	11.3	-	-	-	-	-	-
5-7-76	140	31.5	11.6	9.30	9.6	8	0	0	32½	1½	-
12-7-76	60	29.0	11.0	9.15	11.7	-	-	-	-	-	-
19-7-76	120	30.5	11.7	10.07	9.9	0	0	0	42	49	5
26-7-76	790	41.5	16.6	14.36	9.9	-	-	-	-	-	-
3-8-76	930	39.0	10.9	8.95	8.0	5	0	0	23½	70	1½
9-8-76	710	36.0	10.7	10.02	9.0	-	-	-	-	-	-
10-8-76	1306	28.0	10.5	9.16	8.4	1½	0	0	41	57	½
23-8-76	1200	28.0	9.8	8.74	14.4	-	-	-	-	-	-
30-8-76	840	27.0	9.5	9.39	8.6	0	0	0	47	51	1
6-9-76	4350	23.0	7.2	6.14	8.1	-	-	-	-	-	-
13-9-76	3960	20.0	5.7	5.59	8.1	2½	0	0	55½	37½	4½
20-9-76	4130	21.0	5.8	5.64	8.9	-	-	-	-	-	-

Table 127

Epg and blood values of sheep 501 in chronic helminthiasis.

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	260	23.0	8.4	8.30	20.2	5	0	0	44	50	1
14-6-76	120	30.0	10.8	10.60	15.7	-	-	-	-	-	-
21-6-76	640	25.0	9.5	9.03	15.8	13	0	0	32	53½	1½
29-6-76	1000	25.0	9.7	8.49	15.2	-	-	-	-	-	-
5-7-76	1400	23.5	9.9	7.97	13.5	8½	0	0	43	48	1
12-7-76	270	26.0	10.3	8.95	13.0	-	-	-	-	-	-
19-7-76	980	26.5	10.5	9.17	17.7	10	0	0	35½	54½	0
26-7-76	290	27.5	9.5	7.67	12.7	-	-	-	-	-	-
3-8-76	8690	26.5	10.4	8.08	13.0	14	0	0	33½	52	½
9-8-76	1790	26.0	9.0	8.41	12.1	-	-	-	-	-	-
17-8-76	2480	28.0	10.7	9.97	13.1	7	0	0	10	76	1
23-8-76	3280	27.5	9.2	8.37	13.8	-	-	-	-	-	-
30-8-76	2260	27.5	9.5	8.92	15.4	8½	0	0	74	55	2½
6-9-76	1610	24.5	7.7	7.30	13.9	-	-	-	-	-	-
20-9-76	2100	27.0	8.1	7.99	14.9	-	-	-	-	-	-
9-10-76	4900	30.0	8.1	7.51	11.1	-	-	-	-	-	-

Table 128

Epg and blood values of sheep 502 in chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	30	28.5	10.6	10.82	10.9	13½	0	0	33½	53	0
14-6-76	1270	26.0	8.8	9.66	9.0	-	-	-	-	-	-
21-6-76	450	29.0	10.5	10.26	7.2	2½	0	0	46½	51	0
5-7-76	440	29.5	10.8	7.51	8.1	5½	0	0	49½	44	1
12-7-76	20	30.5	11.3	9.32	10.3	-	-	-	-	-	-
19-7-76	160	27.5	9.6	8.49	8.5	12	0	1	45	41	1½
26-7-76	270	27.0	10.3	8.68	6.7	-	-	-	-	-	-
3-8-76	510	25.5	9.4	8.25	7.3	-	-	-	-	-	-
9-8-76	370	23.5	10.0	10.26	10.3	-	-	-	-	-	-
16-8-76	680	27.0	9.4	8.73	7.7	7	0	1	49	83	0
23-8-76	5230	26.0	8.7	8.17	9.0	-	-	-	-	-	-
6-9-76	3420	22.5	6.1	5.36	6.3	-	-	-	-	-	-
20-9-76	7920	19.0	5.2	5.64	7.5	-	-	-	-	-	-
27-9-76	1080	22.5	7.2	6.90	11.3	10	0	0	63	27	0
4-10-76	680	23.5	7.7	7.95	11.1	-	-	-	-	-	-

Table 129

Epg and blood values of sheep 503 in chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	46	26.0	9.9	8.97	12.4	1½	0	½	19	78	1½
14-6-76	310	32.0	11.6	9.69	12.5	-	-	-	-	-	-
21-6-76	340	31.0	10.4	9.42	10.4	0	0	19	77	0	
29-6-76	400	29.0	9.5	8.19	9.4	-	-	-	-	-	-
5-7-76	0	21.0	9.4	7.14	11.7	4½	0	0	36	58½	1
12-7-76	500	23.5	8.9	7.59	11.6	-	-	-	-	-	-
19-7-76	470	25.1	9.1	7.48	12.3	8	0	0	36½	55½	0
26-7-76	960	26.0	8.1	7.15	9.5	-	-	-	-	-	-
3-8-76	1680	24.0	9.4	7.55	11.9	6½	0	0	41	52	½
9-8-76	2900	25.0	8.9	8.75	12.7	-	-	-	-	-	-
16-8-76	3380	24.5	8.6	7.71	14.0	5½	0	½	44	49	1
23-8-76	3510	23.5	7.8	6.99	10.3	-	-	-	-	-	-
30-8-76	4700	20.0	10.2	9.93	11.5	0	0	61	39	0	
6-9-76	3170	27.5	8.6	7.93	16.1	-	-	-	-	-	-
13-9-76	3540	25.5	8.3	9.99	11.9	8	0	0	48½	43½	0
20-9-76	6220	23.5	6.9	5.62	9.8	-	-	-	-	-	-
27-9-76	5200	25.5	8.2	7.56	14.6	3½	0	0	55	43	½
4-10-76	6520	23.0	7.3	6.69	10.6	-	-	-	-	-	-

Table 130

Epg. and blood values of sheep 505 in chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono %
7-6-76	60	29.5	11.2	10.16	12.7	0	0	0	58½	60	1½
14-6-76	80	32.5	10.3	9.55	10.6	-	-	-	-	-	-
21-6-76	20	33.0	10.9	9.70	16.0	2	0	0	55	42	½
29-6-76	50	29.0	11.5	9.39	15.3	-	-	-	-	-	-
5-7-76	20	20.5	11.7	9.52	10.3	1½	0	0	53½	44½	½
12-7-76	300	31.0	11.3	8.49	12.8	-	-	-	-	-	-
19-7-76	230	27.0	10.2	8.45	11.8	8	0	½	43	47	1½
16-7-76	220	26.0	10.2	9.21	12.7	-	-	-	-	-	-
3-8-76	1030	23.0	9.4	7.07	13.4	3	0	0	48	47	1½
9-8-76	1590	24.5	8.1	7.85	9.7	-	-	-	-	-	-
16-8-76	1880	20.5	7.2	6.45	11.4	1	0	1	22	76	0
23-8-76	2400	14.5	6.5	5.96	16.0	-	-	-	-	-	-
30-8-76	3300	20.5	6.8	6.60	19.9	1	0	1	37½	58	2½
6-9-76	300	18.5	5.7	5.92	19.4	-	-	-	-	-	-
13-9-76	7310	18.5	5.6	5.55	12.9	1	0	0	37½	66	½
20-9-76	750	18.5	5.5	5.69	20.6	-	-	-	-	-	-
27-9-76	5040	18.5	6.3	5.69	17.3	1	0	0	54½	44	½
4-10-76	7520	20.0	6.1	5.46	19.7	-	-	-	-	-	-

Table 131

Epg. and blood values of sheep 506 in chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	120	26.5	10.0	9.22	12.0	10½	0	2½	41	42	4
14-6-76	0	28.5	10.7	9.63	11.8	-	-	-	-	-	-
21-6-76	230	26.5	10.5	10.02	12.3	11½	0	0	45	42	1½
29-6-76	60	26.0	9.6	8.81	9.0	-	-	-	-	-	-
5-7-76	70	26.0	9.6	8.32	9.5	6	0	½	55	37½	1
12-7-76	150	28.5	10.5	8.91	9.0	-	-	-	-	-	-
19-7-76	490	26.5	10.2	9.11	10.3	4	0	0	48	47	1
26-7-76	110	24.5	9.6	8.42	7.3	-	-	-	-	-	-
5-8-76	1020	22.5	9.0	6.50	9.1	10	0	0	30½	52	1½
9-8-76	1400	20.5	7.5	8.04	10.3	-	-	-	-	-	-
16-8-76	1130	35.5	8.0	7.24	9.1	6	0	0	28	64	2
23-8-76	1940	25.0	8.9	7.92	11.5	-	-	-	-	-	-
30-8-76	4090	23.5	8.1	8.19	10.6	6½	0	0	40	50½	3
6-9-76	3560	20.0	6.6	5.95	8.4	-	-	-	-	-	-
13-9-76	4000	22.5	6.9	6.60	13.1	-	-	-	-	-	-
20-9-76	5100	22.0	6.0	5.63	16.3	-	-	-	-	-	-
29-9-76	6480	22.0	6.9	6.31	10.3	5½	0	0	50	44½	0
4-10-76	10300	22.0	6.7	5.92	9.6	-	-	-	-	-	-

Table 132

Epg. and blood values of sheep 508 in chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	170	19.5	7.1	6.96	12.8	2½	0	0	45	51½	1
14-6-76	390	25.0	9.3	7.88	11.5	-	-	-	-	-	-
21-6-76	1500	24.0	7.9	8.02	10.5	6½	0	2	38	53	½
29-6-76	230	22.0	7.0	6.54	9.1	-	-	-	-	-	-
5-7-76	280	23.0	8.7	6.55	8.7	4½	0	0	33½	59½	2½
12-7-76	130	25.0	9.2	7.49	9.0	-	-	-	-	-	-
19-7-76	330	23.0	8.5	7.58	12.7						
26-7-76	2010	22.0	8.4	9.53	9.4	-	-	-	-	-	-
3-8-76	4500	21.0	8.3	7.00	9.4	9	0	0	37½	53	½
9-8-76	3130	22.5	7.6	7.72	9.5	-	-	-	-	-	-
16-8-76	6060	22.0	7.5	7.00	10.3	5	0	0	32	57½	½
23-8-76	2320	19.0	6.8	7.51	8.9	-	-	-	-	-	-
30-8-76	1390	20.5	7.2	6.94	11.7	5	0	0	32	63	1
6-9-76	1800	20.5	6.0	5.36	9.0	-	-	-	-	-	-
13-9-76	3740	18.5	6.0	5.70	6.8	3	0	0	32	58	7
20-9-76	3740	17.5	4.7	4.51	6.8	-	-	-	-	-	-
27-9-76	640	18.5	6.1	5.88	9.0	9	0	0	41	51	9
4-10-76	2490	17.0	5.2	5.04	8.7	-	-	-	-	-	-

Table 133

Epg. and blood values of sheep 509 in chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	20	25.5	9.7	8.10	12.2	16	0	½	30½	50½	2½
14-6-76	0	28.0	10.5	9.12	9.1	-	-	-	-	-	-
21-6-76	20	26.0	11.2	10.12	14.0	5½	0	0	27	67½	0
29-6-76	240	37.0	11.3	9.83	16.3	-	-	-	-	-	-
5-7-76	440	28.5	11.0	8.97	13.9	7	0	0	38	55	0
12-7-76	90	25.5	9.7	7.93	10.8	-	-	-	-	-	-
19-7-76	120	19.5	6.7	5.78	11.1	7	0	0	40½	52	½
26-7-76	1700	25.0	9.2	7.23	11.5	-	-	-	-	-	-
3-8-76	1510	24.5	9.6	7.43	11.0	7	0	0	42½	49½	1
9-8-76	1810	25.5	9.0	8.24	12.8	-	-	-	-	-	-
16-8-76	1290	24.5	8.0	7.32	15.0	5½	0	½	47½	46½	0
23-8-76	770	25.5	8.2	8.16	10.9	-	-	-	-	-	-
30-8-76	2650	27.0	9.2	8.24	13.8	15	0	0	45	39½	1½
6-9-76	2920	27.0	7.7	6.88	11.0	-	-	-	-	-	-
13-9-76	2440	26.5	8.9	7.99	15.2	5	0	0	41	59	0
20-9-76	4250	27.0	7.1	6.38	15.2	-	-	-	-	-	-
27-9-76	1790	22.5	7.4	6.74	7.5	2½	0	0	64½	32	1
4-10-76	2170	23.0	7.1	7.12	9.7	-	-	-	-	-	-

Table 134

Epg. and blood values of sheep 511 in chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	40	26.0	9.3	7.81	8.80	5	0	2	36	53	4
14-6-76	90	27.0	8.8	7.64	8.50	-	-	-	-	-	-
21-6-76	360	28.5	8.2	8.71	9.80	9½	0	0	33	57	½
29-6-76	0	31.0	9.0	7.23	8.50	-	-	-	-	-	-
5-7-76	280	21.5	7.5	6.64	7.80	5½	0	0	35½	56	3
12-7-76	160	22.0	8.0	7.49	9.10	-	-	-	-	-	-
19-7-76	520	21.0	8.1	6.66	10,96	3	0	0	52½	44½	0
26-7-76	1490	25.0	8.8	6.84	8.40	-	-	-	-	-	-
3-8-76	2900	29.5	9.5	7.64	12.20	7	0	0	45	46½	1½
9-8-76	2080	25.5	9.4	6.73	10.70	-	-	-	-	-	-
16-8-76	2690	34.5	9.4	13.1	8.41	2	0	2	45	51	0
23-8-76	4310	34.0	7.9	6.8	9.60	-	-	-	-	-	-
30-8-76	2080	24.0	7.7	7.79	11.80	5	0	0	45	48½	1½
6-9-76	3600	23.0	7.3	6.69	9.80	-	-	-	-	-	-
13-9-76	4760	23.5	7.0	7.44	18.10	5½	0	½	47	45	2
20-9-76	2180	22.0	6.0	5.49	9.80	-	-	-	-	-	-
27-9-76	700	26.0	6.1	7.40	13.20	8	0	0	16	44	2
4-10-76	1000	24.0	5.7	5.66	10.80	-	-	-	-	-	-

Table 135

Epg. and blood values of sheep 512 in chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	LYmph. %	Mono. %
7-6-76	210	26.0	9.9	8.78	18.00	15	0	0	27½	51	½
14-6-76	320	26.5	8.7	8.55	14.00	-	-	-	-	-	-
21-6-76	1060	25.6	9.2	8.56	12.92	5	0	0	35½	58½	1
29-6-76	720	24.0	9.1	5.84	11.50	-	-	-	-	-	-
5-7-76	420	25.5	9.4	7.88	12.70	4½	0	0	43	52	½
12-7-76	1380	24.0	9.1	7.42	9.10	-	-	-	-	-	-
19-7-76	870	22.0	8.3	7.42	16.40	2	0	0	42	56	0
26-7-76	1200	21.0	7.8	7.16	10.50	-	-	-	-	-	-
3-8-76	16290	14.0	5.5	4.52	11.70	3½	0	0	36½	57	3
9-8-76	2510	12.0	5.1	4.32	10.80	-	-	-	-	-	-
16-8-76	2430	16.5	6.0	4.52	11.10	3	0	0	32	65	0
23-8-76	6750	18.0	6.5	5.36	15.70	-	-	-	-	-	-
30-8-76	2310	20.0	6.7	6.09	10.50	5	0	½	32	62	½
6-9-76	5460	17.0	6.2	5.64	21.00	-	-	-	-	-	-
13-9-76	8830	18.5	5.7	4.27	13.70	1	0	0	55	43	1
20-9-76	1980	18.5	5.5	5.75	14.30	-	-	-	-	-	-
27-9-76	490	17.0	5.0	5.61	11.50	4½	0	0	26½	68½	1
4-10-76	2730	18.0	6.1	5.14	16.30	-	-	-	-	-	-

Table 136

Epg. and blood values of sheep 515 with chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	140	24.0	9.9	8.89	12.70	9	0	0	49	41	1
14-6-76	60	29.5	8.9	8.49	14.40	-	-	-	-	-	-
21-6-76	280	24.0	8.4	8.41	11.56	4½	0	0	26½	68	1
29-6-76	300	23.0	5.9	5.64	8.90	-	-	-	-	-	-
5-7-76	450	23.0	9.6	8.44	9.60	2½	0	0	46	51½	0
12-7-76	390	24.0	8.7	7.40	10.50	-	-	-	-	-	-
19-7-76	340	20.5	8.6	7.20	12.60	12	0	0	39½	47	1½
26-7-76	730	21.0	8.7	7.59	8.60	-	-	-	-	-	-
3-8-76	1370	22.0	8.8	7.91	9.80	6½	0	0	51½	41	1
9-8-76	1150	24.0	9.0	8.56	11.70	-	-	-	-	-	-
16-8-76	1230	21.0	8.4	7.65	15.30	6	0	0	50½	43½	0
23-8-76	320	20.0	8.0	7.60	12.50	-	-	-	-	-	-
30-8-76	4450	20.0	7.9	6.92	11.70	7	0	0	59½	37	1½
6-9-76	2310	20.5	6.7	6.26	11.10	-	-	-	-	-	-
13-9-76	1280	19.5	7.2	6.69	10.90	6½	0	0	52	39½	2
20-9-76	5260	16.0	6.6	6.88	12.20	-	-	-	-	-	-
21-9-76	6680	19.0	5.1	5.75	11.10	1½	0	0	71	27½	0
4-10-76	4980	15.5	5.2	4.88	11.90	-	-	-	-	-	-

Table 137

Epg. and blood values of sheep 516 in chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	0	39.0	14.2	8.71	10.60	6½	0	0	27½	65	1
14-6-76	0	37.5	14.9	10.96	11.60	-	-	-	-	-	-
21-6-76	0	38.0	12.2	10.90	12.70	1	0	0	26	70½	2½
29-6-76	0	35.0	13.4	10.14	13.10	-	-	-	-	-	-
5-7-76	20	34.0	12.8	10.46	13.40	2½	0	0	36	61	½
12-7-76	0	35.0	12.8	10.67	15.50	-	-	-	-	-	-
19-7-76	30	33.5	13.2	10.96	12.00	6½	0	0	38	55½	0
26-7-76	150	38.0	13.0	10.87	6.60	-	-	-	-	-	-
3-8-76	310	30.5	11.0	10.54	11.70	1	0	0	43	53½	2½
9-8-76	60	31.0	12.8	14.04	16.10	-	-	-	-	-	-
16-8-76	60	34.5	12.2	12.20	11.44	3	0	1	48½	52½	0
23-8-76	2400	31.5	11.1	9.47	10.80	-	-	-	-	-	-
30-8-76	1290	31.0	11.3	10.04	13.10	6	0	0	41½	49½	3
6-9-76	1800	29.5	10.4	10.29	13.30	-	-	-	-	-	-
13-9-76	490	26.5	8.0	7.76	12.50	8	0	0	36½	55	½
20-9-76	790	25.0	6.9	6.44	9.20	-	-	-	-	-	-
27-9-76	1070	25.0	8.1	7.90	9.10	3	0	0	47½	49	½
4-10-76	4610	20.0	6.2	6.21	9.90	-	-	-	-	-	-

Table 138

Epg. and blood values of sheep 519 in chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7	600	24.5	9.3	8.10	8.3	4	0	½	50	44½	1
14-6-76	780	27.0	9.3	8.95	7.7	-	-	-	-	-	-
21-6-76	600	24.5	8.0	6.19	8.0	4	0	1	56	36½	2½
26-6-76	30	13.0	3.9	3.64	2.4	-	-	-	-	-	-
5-7-76	80	22.5	8.4	7.44	6.1	5	0	½	52½	40½	1½
12-7-76	30	19.5	7.5	6.26	6.6	-	-	-	-	-	-
19-7-76	290	16.0	6.0	5.66	8.0	6	0	0	55	39	0
26-7-76	1490	15.7	5.7	4.20	6.1	-	-	-	-	-	-
3-8-76	410	18.0	6.9	8.81	6.9	4½	0	0	42	49½	4
9-8-76	1070	18.5	6.6	6.07	8.3	-	-	-	-	-	-
16-8-76	380	21.5	6.7	6.73	9.5	10	0	0	53	35½	1½
23-8-76	2140	20.5	7.1	5.99	9.8	-	-	-	-	-	-
30-8-76	2470	22.0	7.8	7.36	10.7	1½	0	0	36½	61	0
6-9-76	2650	19.0	6.7	5.11	12.0	-	-	-	-	-	-
13-9-76	1800	19.0	6.6	5.80	8.5	4½	0	0	36½	44	8
20-9-76	1180	19.0	4.3	3.88	5.4	-	-	-	-	-	-
27-9-76	2400	17.5	5.8	5.75	7.8	4	0	0	43½	44½	3
4-10-76	2470	18.5	5.9	5.42	9.5	-	-	-	-	-	-

Table 139

Epg. and blood values of sheep 520 in chronic helminthiasis

DATE	Epg.	PCV. %	HB. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	0	25.0	9.0	8.07	11.1	5½	0	0	28½	61½	3½
14-6-76	20	30.0	9.3	7.55	13.9	-	-	-	-	-	-
21-6-76	60	25.0	8.4	7.58	12.8	-	-	-	-	-	-
29-6-76	100	27.0	8.1	6.95	11.4	-	-	-	-	-	-
5-7-76	250	26.0	9.5	8.23	14.9	13½	0	½	49	37½	0
12-7-76	100	27.0	10.3	8.66	11.0	-	-	-	-	-	-
19-7-76	1030	27.0	10.3	6.81	15.1	7½	0	0	47½	44	1
26-7-76	460	26.5	9.5	8.53	16.9	-	-	-	-	-	-
3-8-76	3730	24.0	9.1	8.03	11.4	9	0	0	46½	44	1
9-8-76	2580	25.5	9.1	9.36	13.4	-	-	-	-	-	-
16-8-76	2330	24.0	8.7	7.77	12.1	2	0	5	34	55	2
23-8-76	500	24.5	8.9	7.42	12.9	-	-	-	-	-	-
30-8-76	360	25.0	8.6	8.98	12.5	7	0	0	36½	53½	3
6-9-76	3820	22.5	6.5	5.95	9.3	-	-	-	-	-	-
13-9-76	3000	19.5	7.2	6.55	13.7	9	0	0	40	47½	2½
20-9-76	760	16.0	3.9	3.68	9.2	-	-	-	-	-	-
27-9-76	500	17.0	5.7	4.41	14.8	8	0	0	59½	31½	1
4-10-76	1500	19.5	9.5	4.07	15.9	-	-	-	-	-	-

Table 140

Epg. and blood values of sheep 522 in chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	0	26.0	9.4	8.49	14.3	½	0	0	43½	46½	1
14-6-76	40	26.0	9.9	9.08	15.3	-	-	-	-	-	-
21-6-76	340	28.0	8.4	9.22	11.9	4	0	0	36	49½	½
29-6-76	340	32.0	10.0	7.14	6.7	-	-	-	-	-	-
5-7-76	110	28,5	10.1	8.66	9.3	4½	0	0	49	46½	0
12-7-76	30	26.5	9.9	7.92	11.6	-	-	-	-	-	-
19-7-76	200	25.0	9.8	8.74	9.7	3	0	0	51	45½	½
26-7-76	570	28.0	10.2	9.27	8.9	-	-	-	-	-	-
3-8-76	420	27.0	10.8	9.14	12.9	5	0	0	41	53½	½
9-8-76	790	30.5	10.9	10.90	13.8	-	-	-	-	-	-
16-8-76	320	29.0	10.4	9.51	10.4	2	0	1½	39	56½	1
23-8-76	120	27.0	9.6	9.77	9.7	-	-	-	-	-	-
30-8-76	480	24.5	10.5	9.54	13.2	3	0	2½	55	39	½
6-9-76	2670	29.0	9.3	8.85	12.3	-	-	-	-	-	-
13-9-76	1730	29.5	9.3	9.17	15.8	½	0	0	52½	46	1
20-9-76	*NF	28.0	8.8	9.18	15.0						
27-9-76	2320	25.5	8.5	6.92	16.8	2	0	0	53½	43	1½
4-10-76	1510	25.0	7.8	6.31	14.4	-	-	-	-	-	-

Table 141

Epg. and blood values of sheep 525 in chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	340	28.0	10.5	9.83	11.8	4½	0	0	18	75	2½
14-6-76	520	26.0	8.4	7.63	9.2	-	-	-	-	-	-
21-6-76	2060	29.0	13.4	9.23	13.5	0	0	0	24½	67½	2
29-6-76	870	25.0	9.4	5.64	14.3	-	-	-	-	-	-
5-7-76	770	26.0	9.0	6.56	11.5	3	0	0	13½	82	2
12-7-76	590	27.0	10.0	8.19	14.3	-	-	-	-	-	-
19-7-76	780	24.5	9.2	7.58	14.7	6½	0	0	29	64½	0
26-7-76	1770	23.5	8.8	8.12	10.3	-	-	-	-	-	-
3-8-76	2720	19.5	7.6	6.12	12.6	-	-	-	-	-	-
9-8-76	3040	22.0	7.8	7.30	15.8	-	-	-	-	-	-
16-8-76	5690	17.0	5.6	5.13	19.6	5	0	1	32	60	2
23-8-76	3310	16.5	5.6	4.55	8.90	-	-	-	-	-	-
30-8-76	9740	16.5	5.7	5.03	9.7	1	0	0	32	69	0
6-9-76	7220	18.5	4.7	4.91	9.0	-	-	-	-	-	-
13-9-76	6410	16.0	4.7	4.15	11.1	1½	0	0	47	50½	1
20-9-76	10990	14.0	3.4	3.07	13.7	-	-	-	-	-	-
27-9-76	11500	14.0	4.4	3.46	13.4	2	0	0	35	63	0
4-10-76	37970	13.0	4.1	3.11	14.1	-	-	-	-	-	-

Table 142

Epg. and blood values of sheep 528 in chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	2500	25.0	8.7	7.88	14.1	7½	0	0	50	42½	0
14-6-76	800	26.0	9.3	8.30	14.9	-	-	-	-	-	-
21-6-76	1860	25.0	9.1	9.14	18.8	5½	0	0	50	42	2½
29-6-76	800	24.0	11.4	8.73	14.0	-	-	-	-	-	-
5-7-76	1620	25.0	9.3	7.24	14.2	6	0	0	51	42½	½
12-7-76	1840	26.0	9.5	8.05	14.8	-	-	-	-	-	-
19-7-76	820	26.0	9.6	8.62	14.7	9½	0	0	50½	35½	4½
26-7-76	3230	26.0	10.1	8.92	13.7	-	-	-	-	-	-
3-8-76	1780	29.0	10.6	9.02	17.3	-	-	-	-	-	-
16-8-76	1300	28.0	10.0	9.27	15.1	2½	0	0	47½	50	0
23-8-76	1300	26.5	9.5	8.36	15.8	-	-	-	-	-	-
30-8-76	4530	26.5	9.9	9.32	17.6	2½	0	0	46½	50	1
6-9-76	1760	29.5	7.7	7.33	12.6	-	-	-	-	-	-
13-9-76	3030	25.5	8.9	8.23	17.0	6	0	0	50	42	2
27-9-76	1920	26.0	9.4	8.44	15.4	1½	0	0	55½	42	1
4-10-76	1490	26.5	9.0	8.25	14.1	-	-	-	-	-	-

Table 143

Epg. and blood values of sheep 549 with chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	300	40.5	15.1	10.90	18.3	2	0	0	32½	64½	1
14-6-76	30	41.0	14.9	10.29	20.0	-	-	-	-	-	-
21-6-76	30	38.0	12.4	10.96	17.0	½	0	0	26½	73	0
29-6-76	190	37.0	13.4	10.42	14.3	-	-	-	-	-	-
5-7-76	340	35.0	13.2	10.94	14.0	1	0	0	36	63	0
12-7-76	110	33.0	12.4	10.50	14.0	-	-	-	-	-	-
19-7-76	360	26.5	10.2	8.69	11.8	6½	0	0	29	60	4½
26-7-76	620	27.5	9.8	8.17	11.9	-	-	-	-	-	-
3-8-76	2280	29.5	11.1	9.74	15.4	-	-	-	-	-	-
9-8-76	3120	30.0	9.8	10.05	17.2	-	-	-	-	-	-
16-8-76	1150	29.5	10.2	8.20	18.4	2	0	0	34	63	1
23-8-76	4120	29.0	10.4	9.46	12.3	-	-	-	-	-	-
30-8-76	3090	30.0	11.7	10.64	17.9	1	0	0	38½	59	1½
6-9-76	9670	29.5	9.0	8.38	13.8	-	-	-	-	-	-
13-9-76	1090	24.0	9.7	9.32	12.3	½	0	0	40	57	2½
20-9-76	3730	26.0	7.1	6.73	11.3	-	-	-	-	-	-
27-9-76	3200	24.0	9.1	8.32	15.3	0	0	0	-	-	-
4-10-76	4270	23.0	7.7	7.90	15.6	-	-	-	-	-	-

Table 144

Epg. and blood values of sheep 576 in chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	0	27.5	10.5	7.36	7.3	3	0	0	43	48½	5½
14-6-76	0	25.0	8.9	9.90	9.1	-	-	-	-	-	-
21-6-76	0	25.0	8.6	10.26	8.3	7	0	1	41	47	4
29-6-76	760	24.0	10.1	8.11	6.0	-	-	-	-	-	-
5-7-76	840	22.5	8.6	7.80	7.0	½	0	0	46	51	1½
12-7-76	-	19.5	7.6	6.67	7.1	-	-	-	-	-	-
19-7-76	610	16.0	6.3	6.30	7.0	2½	0	0	44½	49½	3½
26-7-76	2420	18.0	6.5	6.65	7.8	-	-	-	-	-	-
3-8-76	3190	19.0	6.8	5.96	6.7	4	0	0	51½	44½	0
16-8-76	1060	19.0	6.3	6.16	7.2	4	0	0	49	47	0
23-8-76	10080	13.0	4.6	5.69	7.6	-	-	-	-	-	-
30-8-76	2090	14.0	4.4	4.73	2.6	7½	0	0	45½	47	0
6-9-76	9860	14.0	4.3	5.04	8.6	-	-	-	-	-	-
13-9-76	17260	12.0	3.9	3.03	8.6	0	0	½	44	55½	0
20-9-76	8340	10.0	2.7	2.25	6.7	-	-	-	-	-	-

Table 145

Epg. and blood values of sheep 584 in chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	0	26.5	9.8	9.64	15.4	0	0	0	51½	47	1½
14-6-76	40	28.5	10.4	9.50	7.8	-	-	-	-	-	-
21-6-76	3940	28.0	7.6	7.59	9.1	2	0	0	48	48½	2
29-6-76	0	23.0	8.3	6.22	8.8	-	-	-	-	-	-
5-7-76	170	22.5	8.7	7.19	8.7	3	0	0	37	59	1
12-7-76	540	19.0	7.3	6.86	7.8	-	-	-	-	-	-
19-7-76	850	18.0	6.9	5.88	7.3	4½	0	½	45	49½	½
26-7-76	1070	22.0	8.3	7.55	6.2	-	-	-	-	-	-
3-8-76	2100	24.5	9.2	7.58	8.6	3½	0	0	44	53	0
9-8-76	2270	24.5	8.9	8.03	11.4	-	-	-	-	-	-
16-8-76	1300	24.0	8.2	7.30	11.3	½	0	2	50	47½	0
23-8-76	2360	20.0	7.1	6.33	16.2	-	-	-	-	-	-
30-8-76	3700	19.0	6.7	5.99	16.9	2	0	0	44½	51½	2
6-9-75	4500	20.0	6.2	5.78	12.0	-	-	-	-	-	-
13-9-76	4320	18.0	6.1	5.69	13.1	1½	0	0	40	56½	2
20-9-76	2900	18.0	5.3	4.87	13.3	-	-	-	-	-	-
4-10-76	2400	17.5	5.7	5.88	9.6	-	-	-	-	-	-

Table 146

Epg. and blood values of sheep 596 in chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	0	36.5	13.50	12.98	20.8	4½	0	0	66½	27	2
14-6-76	0	34.5	11.60	10.90	13.2	-	-	-	-	-	-
21-6-76	120	22.0	13.00	10.94	19.1	3½	0	0	49½	47	0
29-6-76	30	33.0	8.91	10.24	10.7	-	-	-	-	-	-
5-7-76	90	30.0	12.20	9.34	13.1	3½	0	0	50	46½	0
12-7-76	140	32.5	12.30	10.20	14.8	-	-	-	-	-	-
19-7-76	90	31.0	11.60	10.00	17.3	3½	0	0	46	49	1½
26-7-76	1040	31.0	11.30	8.49	10.7	-	-	-	-	-	-
3-8-76	1330	30.5	11.60	10.74	16.1	-	-	-	-	-	-
9-8-76	2070	30.5	11.50	10.96	21.1	-	-	-	-	-	-
16-8-76	4400	26.5	9.20	8.45	18.1	4	0	1	48½	46½	0
23-8-76	10590	24.0	8.37	7.37	16.9	-	-	-	-	-	-
30-8-76	1890	22.5	7.30	6.96	26.9	6	0	0	54½	35½	4
6-9-76	9890	21.0	7.10	6.81	21.2	-	-	-	-	-	-
13-9-76	6900	17.5	5.30	4.44	10.6	2½	0	0	45½	50	4
20-9-76	21870	13.0	4.60	4.05	14.8	-	-	-	-	-	-
4-10-76	23100	17.0	5.40	5.94	19.7	-	-	-	-	-	-

Table 147

Epg. and blood values of sheep 1107 in chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	0	21.0	9.8	9.83	12.9	1	0	0	30½	68	½
14-6-76	0	28.0	9.9	9.33	11.3	-	-	-	-	-	-
21-6-76	196	25.0	9.0	9.19	16.1	0	0	0	66½	33½	0
29-6-76	40	24.0	8.9	7.97	10.9	-	-	-	-	-	-
5-7-76	290	27.5	9.2	7.83	11.7	1	0	½	44	52½	2
12-7-76	70	23.4	8.4	6.72	14.0	-	-	-	-	-	-
19-7-76	680	24.5	8.8	7.92	11.0	4	0	0	38½	55	2½
26-7-76	470	23.0	8.9	8.17	5.2	-	-	-	-	-	-
3-8-76	730	19.5	8.0	7.08	8.0	3	0	0	31	63	3
9-8-76	1780	20.0	6.7	6.46	10.9	-	-	-	-	-	-
16-8-76	1400	20.5	7.5	6.81	14.7	4	0	2	50	55	0
23-8-76	6080	21.0	6.8	5.64	6.7	-	-	-	-	-	-
30-8-76	430	20.0	7.0	6.69	16.4	5½	0	0	63	30	1½
6-9-76	2700	20.0	5.5	5.74	14.3	-	-	-	-	-	-
13-9-76	5470	17.0	4.9	4.42	6.0	4	0	2	53	40½	½
20-9-76	6110	14.0	3.9	2.83	6.8	-	-	-	-	-	-
27-9-76	1700	17.0	5.9	4.39	14.8	1	0	0	59½	39½	0
4-10-76	7260	16.0	5.9	5.63	12.1	-	-	-	-	-	-

Table 148

Epg. and blood values of sheep 1111 in chronic helminthiasis

DATE	Epg.	PCV. %	Hb. g/dl	RBC. 10^6/cmm	WBC. 10^3/cmm	Eosin. %	Baso. %	Band. %	Segm. %	Lymph. %	Mono. %
7-6-76	0	21.0	8.1	8.03	8.7	0	0	0	43	53	4
14-6-76	0	25.0	8.7	9.27	7.3	-	-	-	-	-	-
21-6-76	50	26.0	8.4	8.05	9.2	2½	0	1	43½	52	1
29-6-76	30	23.0	10.8	9.58	7.0	-	-	-	-	-	-
5-7-76	1160	27.0	9.8	8.25	7.6	2	0	0	53	44	1
12-7-76	2000	25.0	9.2	8.11	9.4	-	-	-	-	-	-
19-7-76	2190	Clotted									
26-7-76	2340	22.0	8.1	6.78	6.0	-	-	-	-	-	-
3-8-76	3570	19.5	7.4	6.69	7.4	5	0	0	44	48	3
9-8-76	2270	19.5	6.4	6.55	8.2	-	-	-	-	-	-
16-8-76	3100	22.5	7.2	6.45	7.3	½	0	1½	50	47	1
23-8-76	3030	20.5	7.0	5.64	15.0	-	-	-	-	-	-
30-8-76	5430	19.0	6.3	5.63	18.2	3	0	0	60	36	1
6-9-76	12870	13.0	6.2	5.64	13.6	-	-	-	-	-	-
13-9-76	5090	17.0	5.2	4.65	12.1	4	0	0	60	74½	1½
20-9-76	5700	14.0	3.6	3.37	13.9	-	-	-	-	-	-
27-9-76	12820	13.0	4.0	3.63	12.3	2	0	0	52½	42½	3
4-10-76	8900	14.5	3.5	2.41	13.0	-	-	-	-	-	-

Table 149

Worms recovered from the group of sheep with chronic infection

No.	Haemonchus spp		Trichostrongylus spp		Strongyloides spp.	Others
	Adult	Immature	Adult	Immature		
495	120	7000	14000	300	0	0
499	500	3100	11400	0	0	0
500	700	3000	7500	600	200	0
501	300	8500	21000	200	0	0
502	0	10000	12200	0	400	400
503	0	6500	14400	0	0	0
505	200	12000	14200	800	0	0
506	200	4200	13700	100	0	0
508	0	8000	4800	700	300	0
509	100	5000	19100	1100	800	0
511	0	11000	18600	0	0	100
512	200	16000	15900	400	0	0
515	800	3500	13100	800	0	200
516	100	6000	17400	200	2600	0
519	600	2800	11000	200	0	0
520	200	4000	9600	1000	0	0
522	300	10000	7000	7000	100	0
525	200	18100	14100	0	100	100
528	0	5400	21000	0	0	0
549	100	3000	6500	500	300	0
576	300	7200	12800	300	0	300
584	0	4700	9700	300	0	0
596	400	9000	17000	900	100	0
1107	0	2000	8200	0	0	0
1111	0	13000	11100	200	0	0

THE EPIDEMIOLOGY OF TRICHOSTRONGYLID INFECTIONS OF SHEEP IN THE NORTHERN GUINEA SAVANNA OF NIGERIA

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AN ABSTRACT OF A THESIS

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Pasture infectivity in the northern Guinea Savanna of Nigeria, the epidemiology of inhibited trichostrongylid larvae, resistance of these inhibited larvae to anthelmintics and some haematological changes in groups of sheep suffering from acute and chronic helminthiasis were the objects of this study.

Analysis of pasture infectivity by monthly worm counts in tracer lambs revealed that large numbers of infective larvae were picked up on pasture from June to October. From November onwards, the number of infective larvae on pasture decreased gradually until the middle of January when no more larvae were acquired. Sterility of the pasture remained in this form until the later part of May when infectivity resumed due to availability of adequate moisture.

Studies on inhibited development of trichostrongylid larvae using groups of ewes and lambs showed that only the species of Haemonchus and Trichostrongylus do exhibit inhibited development in the Northern Guinea area. High rates of inhibition were found in Haemonchus contortus throughout the dry season. At the end of the rainy season, high level of inhibited development of larvae were obtained in 2 lambs infected experimentally with infective larvae cultured for 7 days at 27°C, suggesting that the capability to go into inhibition may be determined by the genetical constitution of the larvae and not only determined by environmental conditions on pasture acting on the infective larvae.

Degree of inhibition in Trichostrongylus spp. is quite low compared to Haemonchus spp. Inhibited larvae come out of inhibition in April at the onset of the rainy season.

Anthelmintic trials against inhibited trichostrongyle larvae using Nemafax, Thiabendazole, Ranide and Loxon 2 at varying dosages showed that Nemafax and Thiabendazole at 100 mg/kg. and 200 mg/kg. body weight, were highly effective against inhibited larvae. At 50 mg/kg however, they were not quite effective.

Ranide at a dosage as high as 15.16 mg/kg and Loxon 2 at a dosage of 51 mg/kg body weight gave unsatisfactory results, against inhibited trichostrongyle larvae.

Systematic observations of blood changes of sheep with acute and chronic helminthiasis revealed that in the group which suffered from acute helminthiasis, there was a quick rise in helminth egg output with corresponding rapid fall in PCV, Hb, and RBC values. Progressive increase in neutrophils and progressive decline in lymphocyte values were observed.

In the group with chronic helminthiasis however, helminth egg output increased very gradually. Similarly, there was a gradual fall in PCV, Hb, and RBC values. Fluctuations were observed in the values of eosinophils, lymphocytes and neutrophils.